U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-258 815

Upgrading Dairy Production Facilities to Control Polution In-Plant Control of Waste

Cornell Univ, Ithaca, N Y Dept of Food Science

Prepared for

Environmental Protection Agency, Washington, D C

1973

295041

PB 258 815

Environmental Protection Agency Technology Transfer Program

UPGRADING DAIRY PRODUCTION FACILITIES TO CONTROL POLLUTION

IN-PLANT CONTROL OF WASTE

SEMINAR SERIES FOR POLLUTION CONTROL

MADISON, WISCONSIN
MARCH 20,21,1973

DEPARTMENT OF FOOD SCIENCE
CORNELL UNIVERSITY
ITHACA, NEW YORK

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

BIBLIOGRAPHIC DATA SHEET	1. Report No.	2.	3. Recipient's Accession No. PB-258 815
4. Title and Subtitle Upgrading Dairy Production Facilities to Control Pollution. In-Plant Control of Waste.			5. Report Date 1973 6.
7. Author(s) Robert R. Zall, and William K. Jordan.			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Cornell University Ithaca, New York Department of Food Science			10. Project/Task/Work Unit No. 11. Contract/Grant No.
12. Sponsoring Organization Name and Address			13. Type of Report & Period Covered 14.

15. Supplementary Notes Presented at the Environmental Protection Agency Technology Transfer Design Seminar, held at Madison, Wisconsin, March 20-21, 1973. See also PB-258 816. (PC A05/MF A01)

16. Abstracts

Contents:
Overview of selected plant problems; Case study - New York plant; Detergent evaluation; Segregation of dairy wastes for recycling; Waste dilution, monitoring information, and volume reduction.

17. Key Words and Document Analysis. 17a. Descriptors

*Water pollution abatement
*Dairies
*Agricultural wastes
*Benefit cost analysis
Upgrading
Economic models
Profits
Detergents
Waste water reuse
Dilution
Separation
Monitoring
Losses

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group 13B, 2C

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
National Technical Information Service Springfield, VA 22161	UNCLASSIFIED	83
	20. Security Class (This Page) UNCLASSIFIED	22. Price PC$5.00/ MF$3.00

FORM NTIS-35 (REV. 10-73) ENDORSED BY ANSI AND UNESCO. THIS FORM MAY BE REPRODUCED USCOMM-DC 8265-P74

UPGRADING DAIRY PRODUCTION FACILITIES TO CONTROL POLLUTION

IN-PLANT CONTROL OF WASTE

Technology Transfer Design Seminar

Madison, Wisconsin

March 20 - March 21, 1973

Prepared for the

Environmental Protection Agency

by

Robert R. Zall, Ph.D.

and

William K. Jordan, Ph.D.

Department of Food Science

Cornell University

Ithaca, New York 14850

Table of Contents

Page No.

List of Tables ii

List of Figures iii

INTRODUCTION 1

PART I. OVERVIEW OF SELECTED PLANT PROBLEMS
- Phantom Losses 2
- Profits and Economic Models 3
- Plant Impact on Waste and Profits 4
- Our People Problem 5
- Training 6
- Planning the Work Load 7

PART II. CASE STUDY - NEW YORK PLANT 8
- Operating Hours 10
- Representative Sampling Program 11
- Initial Survey 13

PART III. DETERGENT EVALUATION 15
- Reuse of Detergents 15
- Quick Test for Detergent Concentration 16
- Each Detergent Must Be Tested for Characteristics 20
- H.T.S.T. Circulation 20

PART IV. SEGREGATION OF DAIRY WASTES FOR RECYCLING 23
- Ice Cream Mix Waste 24
- Freezer Waste 24
- Visual Determination of Dilution End Point 25
- Other Testing Guidelines 25

PART V. RESULTS AND MEANING 34
- Waste Dilution 34
- Monitoring Information 34
- Volume Reduction 35
- Temperature Reduction 36
- Decrease of Btu to Sewers 37
- Fuel Economy 44
- Temperature Relationship 44
- Waste Segregation Value 45
- Reduction in Pounds of BOD 49
- Reduction in Use of Cleaning Compounds 54
- Efficiency Should Supersede Appearance 57
- Fat Losses 58
- Value of Waste Monitoring 59

SUMMARY 63A

APPENDIX A 68

REFERENCES 73

List of Tables

Page

1. Ability of Sour Milk Micro-organisms to Grow in Detergent Substrates 17
2. Use of Solu-bridge Model RD-4 Industrial Instrument . . . 27
3. Composition of Samples Obtained at Five Second Intervals After the Start of Rinsing 29
4. Conductivity of Water Solutions or Suspensions of Some Common Components of Dairy By-products Using Solu-bridge RD-4 31
5. Salvaged Dairy Products Rinsings 40
6. Effluent pH 51
7. pH Reading Using a Beckman Model Zeromatic II pH Meter . . 52
8. Product Quality Control 56
9. Estimated Savings Available at Plant When Rinsings are Salvaged, Detergents are Reused, and Water Waste is Reduced 60

List of Figures

Page

1. Acid Required to Titrate Detergent to Phenophthalein End Point 21
2. Alkali Required to Titrate Penn San to Phenophthalein End Point 22
3. Total Solids of White Milk and Chocolate Milk Rinsings Collected at Five Second Intervals 32
4. Solu-bridge Readings of Milk and Chocolate Milk Rinsings Collected at Five Second Intervals 33
5. Flow Characteristics - October 20, 1967 38
6. Flow Characteristics - October 23, 1967 39
7. Flow Characteristics - October 25, 1967 40
8. Flow Characteristics - November 8, 1967 41
9. Flow Characteristics - November 10, 1967 42
10. Flow Characteristics - November 13, 1967 43
11. Waste Temperature - October 25, 1967 46
12. Waste Temperature - November 13, 1967 47
13. Concentration vs. pH 53
14. Possible Way in which Waste Monitoring Information Might be Used in a Large Corporation 62
15. View of Shed Constructed to Hold Monitoring Equipment with Clean and Soiled Water Segregation Stations 64
16. Closeup View of Parshall Flume 65
17. Recording Instrument and Composite Sampling Proportional to Flow 66
18. Closeup of Recording Instrument that also Computes Btu Loss in Waste 67

IN-PLANT CONTROL OF WASTE

Waste is often defined in terms of "to spend or use carelessly", "to squander", and "to consume property extravagantly". Another thought on the meaning of waste is "allow to escape without being utilized". In still another version, the Environmental Protection Agency, in an impact statement, coined the phrase "waste is a misplaced resource".

The goal then to be captured by controlling food plant waste might be that which produced a zero discharge. A problem is best solved when we know its magnitude and especially if it is defined in some measurable unit. When both the volume and concentrations of liquid waste are measured, then together they represent known quantities of material. For example, when the engineer designs waste treatment systems, he plans a process to treat pounds of BOD. Neither the liquid volume by itself nor the waste concentration knowledge alone supplies enough information to intelligently treat waste.

Historically and even today, most food plants fail to measure wastes as a separate identifiable by-product. Most often management recognizes their raw products recovery in terms of finished food yields as percentages or as pounds per ton of raw ingredients. Other yield phrases are used that are common to specific industries.

Because record keeping is expensive and has increased enormously in all industries due perhaps to Internal Revenue edicts or newer methods to record cash flow customs, food plant operators tend to economize accounting costs by minimizing internal process record controls. Traditionally, the Dairy Industry has been a football for all sorts of agencies that require

much documenting due to health department records and marketing pricing reports ordered by Federal marketing administrators. It is therefore only natural that most plants try to avoid duplicate accounting by substituting required record systems of others in operating their milk facility. Be the plant a milk filling-distribution operation or a multi-product manufacturing unit, both need in-line process accounting information to properly monitor day-to-day operation. These records most usually should be tailored to fit the individual needs of the user.

Records should not be generated solely for others because such information reflects the past. Adequate through-flow information should continuously be collected from which either manual or automatic operational changes can be made.

Phantom Losses

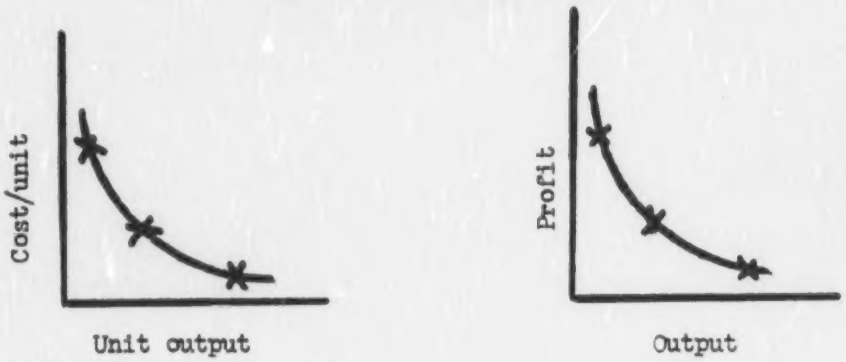
While it is true that each dairy plant has an inherent product loss factor of some magnitude due to its style of piping, vats, fillers, etc., this fact alone does not pinpoint any locations where these losses might be reduced. Product accounting is meant to explain why and where there are differences between receipts and usage, for these are not phantom losses. For example, when management decides to fill one pound cartons of cottage cheese with one pound, two ounces to avoid short weights, then the plant experiences unexplained losses if bookkeeping notations only credit the units for being one pound. This seminar highlights selected areas of milk plant operations that supervisory personnel may wish to compare with their own methods.

We cannot stress enough the value of monitoring inflow operations. Testing a liquid product to a "finely honed" level is excellent but of little value to a plant if the commodity is then wasted by being overfilled into containers.

Profits and Economic Models

Economic models often illustrate, in graphic form, the relationship of costs to output as follows:

Butter Powder Operation



The cost per unit will drop as production is increased. This graph does not go out to infinity. Nor is the slope a smooth line, but rather a series of bumps, hills, and valleys. To the plant with a butter-powder process, for example, the painful example takes the form: as output goes up, the faster profits go down. Let us remember that such a graph is not presented to represent a profit curve because broadly, we think in terms of:

π = Total Revenue - Total Costs

TC = Fixed Costs + Variable Costs

π can be a plus or minus or zero relationship as you all quite obviously know. At first glance, we can perhaps continue to fill a plant with production, but loading plants up with orders that are impractical results too often in chaos, poor products, overtime, equipment failure, and abuse of customers, workers, and management, not to mention an unneeded exercise of hard work that generates little or no profit.

Plant Impact on Waste and Profits

The design and blending of process flows of tanks, vats, coolers, packing machinery, warehousing, and the like begins to separate the men from the boys. Ingenuity and efficiencies of heating, cooling, and material handling are vital cost centers. Size, speed, and hours of operation affect economics. Floor space of equipment related to output should be considered. Down time, one product, one vat, obviously affect equipment utilization.

It has been written by Farrell that construction of a dairy building is a matter of meeting local conditions and generally providing for straight-line movement for ease of supervision. Perhaps one should emphasize that local conditions do not imply Rube Goldberg hookup. Often temporary arrangements remain like cancers and grow widely in all plants unless cut out objectively. Some products, for example, still can best utilize gravity flows. In fact, we must be reminded that pumps of the best design still need power, washing, repair, and replacement.

Time studies, work simplification, and regular scheduled review of procedure by competent experts are all valuable tools to increase profitability for a firm. Product loss, with excessive flushing and cleaning costs, are dramatically affected by in-plant equipment arrangement. Process changes occur faster than the updating of necessary CIP circuits and welded-line changes, often two to one, so plant management should review, frequently, the clean-up flows along lines to save product, labor, detergents, and time.

Characteristics of products must be evaluated to achieve a balance of value. The text book definition of curd identity versus the real world product that can be manufactured at reasonable cost is always a problem. Processing methods directly or indirectly exert a sizable impact on costs as well as quality. In my opinion, there are no free rides in business.

All activity creates costs and also a lack of activity means still an added cost.

Our People Problem

When we talk of quick returns or quick corrective action to be made affecting the waste situation in operations, let me dwell on our problem of people. Probably no firm represented here (and let us also include the members of the academic community), is not troubled daily with problems created by men and women. Probably no treatment of the "people problem" receives so little review in our dairy industry literature as the impact of the shortage of trained technical people to the economics of production and sales. While this "people problem" is acute to our general dairy operations, to the cultured industry, our lack of trained individuals in all areas of both sales and production is without parallel and contributes enormously to real costs and waste of doing business.

Let's look at a new breed of specialist needed in the dairy plant whose importance has become far more enlarged as we seek sophistication through automation...the button pusher and mechanic who now opens the little black bag, the new status symbol for whom all must wait in the automatic production line until the mass of relays click in proper rhythm. We have a real bearcat; and trained workers, unafraid of buttons and lights are required in a plant of the 70's. Conditions have become so bad throughout the country, that in many plants even the most mediocre technicians have gained positions of prominence. Top management has come to compromise more and more with work quality by accepting inferior workmanship. The idea that such and such or so and so is better than nothing is becoming a frightening rationale.

The applicant for work today is different by far from those of other generations. If he is aware of the depression of the 30's, certainly he is

not impressed by it and will not consider himself lucky just to have a job. If you manage initially to gain some respect through the interview or by corporate image, try not to anticipate the new employee will follow direction through fear of job loss, for he has survived over a quarter of a century, living constantly under a nuclear bomb threat. If you talk war years, probably he will have to ask which one---World War I, II, Korea, Vietnam. His attitude regarding the union is different. Seniority and job security concepts vary from his dad's attitude. He wants top scale and benefits at once and will not be willing to wait for anything. Often he can resent workers standing in his way of progress when he can work faster than they.

Training

The new worker is fast, quick to learn, very well informed, quite worldly, generally mechanically inclined. Picture him with a bucket, brush, boots, and a wet pair of overalls, scooping cheese from a vat. To train him and ourselves in the new ball game is quite a trick! The new applicant to our dairy plants wants instruction in his job as to why biologically or chemically. He is, more often than not, well-educated, and expects training from a competent, articulate supervisor. He would rather run multiple automatic casing equipment than stand on a line packing cups or jars all day. The new, young employee has been a television watcher from childhood, and once having been conditioned to computers, robots, and the like, now can hardly be expected to become job enthusiastic by scrubbing walls and floors, no matter how vital it is to the operation. Given a job opportunity in a more alluring industry, he will soon be gone.

Training workers for dignified food work is the real task and heartache for management. A firm, providing the ideal plant with fine equipment, will do itself a disservice if they man the location with people, using the better-than-nothing rationale. When speaking of competency, it does not infer

that a single bright manager is the cure-all, for he who believes the manager alone runs the plant will soon find he must work through others simply because he can't do all the jobs, around the clock, seven days a week!

Planning the Work Load

Scheduling, a key ingredient which is frequently overlooked, is one of the best waste controls in a food plant. Running chocolate milk between two white products is an obviously unacceptable practice because it most often requires some water rinsing between products with ultimate flushing of liquids into a sewer.

Shutdowns, regardless of cause, represent lost time that never can be recaptured. Interruptions in continuous operations most always produce a product loss. Enlightened operators know that employee memories are short. A production worker may well remember yesterday's reasons for delay and loss but probably not the problems of two days ago. Documentation is needed in form of a written log or preferably a recording chart that highlights variances from norms. For example, if a bottling line is frequently shut down waiting for cases, then the reasons "why" must be explained. If the down time is waiting for product, repairs, lunch periods, etc., then a tabulation of time with an evaluation of changes to increase efficiency can be made if the records have been properly assembled.

Running a plant by guess work or by "the seat of the pants" is not the acceptable method to keep any business healthy and waste-free.

The Harvard School of Business pioneered the case study method of teaching business executives how to be better managers. This technique should also work well for teaching ourselves "in-plant control of waste" by looking at a single site and then applying the ground rules to our own

specific plants. Larger plants can consider a small New York dairy plant study to be similar to a part of their operation. Big or small numbers do not change the methodology of how to abate waste pollution by improving in-house management.

Case Study of a New York State Dairy Plant

Waste Measurement

The case study procedure was designed to obtain information from an operating food plant before and after its personnel were aware of a waste sampling program. In addition, the effects of waste minimization would be monitored and recorded to give permanent records of changes that occurred.

Continuous recording instruments were used to provide permanent records of temperature in degrees Fahrenheit and flow in inches of rise across the ninety-degree V-notch weir. Later in the experiment, modifications were made to include a pump and tanks with an automatic sampling device that allowed collection of out-fall pipe information while the investigator was free to observe practices in use in the dairy plant where the effluent originated.

The investigator conducted a waste minimization educational program for the plant workers. After this the plant workers were kept informed as to the amount of waste water going down the drain. This was done hourly by posting information on water use.

Waste in the form of rinsings from lines and equipment used in the operation of the dairy plant was partially segregated to reduce product loss to the sewer. The volume of the gathered materials and their fat and solid non-fat contents were measured. In addition the conductivity and pH of the rinsings were determined.

As rinsing of a piece of equipment progresses the concentration of materials in the rinse water decreases. At some point the concentration decreases where it is no longer worth saving. A quick test to indicate where this point has been reached is desirable. Tests showed that conductivity of the rinse water could serve as the desired index as shown in Table 3.

In addition, used cleaning solutions were collected and checked for potential reuse characteristics. Titration curves to measure detergent strength were established for the specific cleaning compounds used in the dairy plant. The necessary makeup additions of fresh chemicals to the previously used detergent solutions were determined by titration.

A bacteriological evaluation of the inhibitory qualities of the used cleaning compounds was done to determine the proper storage concentration range for segregated cleaning fluids. When previously used detergents were experimentally employed to clean the High Temperature Short Time, the dairy products processed through it were checked for bacterial content according to Standard Methods.

Operating Hours

During the study, the New York dairy plant operated on a shift and one-half basis, similar to many small pasteurizing plants. The first employee arrived shortly before five in the morning and started sanitizing lines and equipment. His main work was that of pasteurizing and by-product assimilation. He also acted in the capacity of a working foreman for the operation. About an hour later the working day started for three men who individually operated a Seal King carton filling machine, a Poly-Gal bulk filler, and a Tetra-Pak coffee cream filling machine.

The filling operation and washing operation were normally completed by 1:00 p.m. when most of the employees left. The plant also conducts a sizable ice cream freezing operation. Volumes in excess of 150 cans of mix per week were frozen in the plant. Freezing started later in the day and was generally completed, including the wash-up, by 5:00 p.m. A full-time employee and a part-time worker were involved between 8:00 a.m. and 5:00 p.m.

The starting and stopping of the operations resulted in changes in flow rate of water going to the sewer. This information, when recorded, showed the start-up time, processing hours, and CIP wash cycles with high peaking.

In addition, waste monitoring showed a quiescent time between 2:00 p.m. to 4:00 p.m. when little or no waste was generated. The final peak in the flow rate of waste resulted from the clean-up of the freezer and auxiliary packaging machinery.

Reproduced from best available copy.

Representative Sampling Program

It was evident from early trial operations that waste from the dairy plant came in surges of contaminants rather than as a uniform flow. Observation at the outfall pipe convinced the investigator of the chance of obtaining erroneous results when samples are gathered on a time basis. For example, a surge of chocolate milk waste would appear in the weir box and last less than three minutes when it was replaced with clear water or some other commodity. A sampling program of fifteen minute cycles or even ten minute cycles could yield composite samples with extreme variations. Samples had to be taken in amounts proportional to flow volume to be significant.

The results of one experiment in which samples were taken at thirty minute intervals showed an apparent BOD load equal to four times the value obtained by more reliable sampling methods. On the other hand, sampling at thirty minute intervals could have given a BOD value lower than the correct one had chance retimed the sampling to clear water periods.

Additional Guidelines in Data

A recording thermometer was employed to give temperature information on the waste flow. It became evident that positive contributions were derived from such data. In addition to yielding information as to waste temperature fluctuations, the chart brought to light an excessive use of hot water caused by improper operation of a vat pasteurizer.

A Solu-Bridge conductivity apparatus was used in the early stages of the work to see if any correlation existed between conductivity and changing milk concentrations in waste water. Unfortunately varied

waste concentration produced only minor differences in the instrument readings. It was worthwhile to note that detergents, acids, and chocolate showed more quantitative differences. Further investigation with conductivity was conducted and is discussed in the product segregation portion of the investigation.

Gravimetric Methods

The waste composite sample was analyzed using a Mojonnier tester for total solids and ether fat extraction. The fat and total solids concentrations were too low to be measured accurately by the Mojonnier test. The analyst, therefore, did not base judgment on data obtained by this method.

BOD Determinations

The most common method of indicating concentration of wastes regardless of their source is the Biological Oxygen Demand. BOD is the amount of oxygen in mg/l used by micro-organisms to consume biodegradable organics in waste water under aerobic conditions. Composite samples obtained by the sampling program were tested for this relationship and the results were used as the index of waste concentration contributed by the dairy to the sewer system. The index obtained can also be converted to a population equivalent where an individual is said to contribute 0.17 pounds of BOD per day. Pounds of BOD can be obtained by knowing the BOD of the waste, the gallons of waste, and the weight per gallon of waste material.

$$\text{*Pounds BOD} = \frac{\text{BOD} \times \text{number of gallons} \times \text{wt/gal}}{1{,}000{,}000}$$

*J.C. White "Dairy Waste Disposal Costs" American Dairy Review (J-1-65)

Reproduced from best available copy.

Initial Survey - Keeping Plant Personnel Unaware of Testing

For the case study to have been significant, it was vital that differences in flow pattern from the milk plant be recorded with its existing practices and again after indoctrination of personnel with an educational program outlining waste prevention techniques.

The daily pattern of waste flow was remarkably uniform.

The plant bottled three days per week, and made ice cream mix on the fourth day. The fifth day of operation was allocated to maintenance of equipment and rigorous clean-up of the general area.

The flow charts (see Figures 5 to 10) showed that the personnel formed habits of work patterns. Each in-plant function was repeated on consecutive days with little or no variations. Processing, rinsing, and washing, occurred at regular times unless breakdowns were experienced. Product flow was almost always the same. Skim milk was followed by homogenized milk, which was then followed by chocolate milk.

With three days experience in observing waste discharges, the investigator could predict the characteristics of the flows expected at the laboratory monitoring station.

Change of Tactics

The objective of this phase of the study was to inform the plant personnel and management of the ratio of water consumed to product handled. Anticipated resentment to waste monitoring and expected lack of cooperation did not materialize as the entire compliment was cooperative to a man.

Plant management and the plant workers were kept informed of the monitoring results once the "before" information was determined. Frequent visits were made by all personnel to the laboratory to observe and ask questions about what was being done and why.

All plant personnel were surprised at the volumes of effluents going to the sewer. They had no idea of the amounts of water being utilized to process the products. A peak ratio of seven to one, then a more uniform six water to one milk was recorded for the operation before water conservation practices were stressed. Dilution by a few thousand gallons did occur, but the product loss was quite constant and created similar daily pounds of BOD.

Detergent Evaluation with Follow Up Testing for a Reuse System

Generally, a wide variety of cleaning compounds are used in any one plant in the dairy industry. True to form, many different brands were present in this dairy plant. Too many brands and types of cleaning products can lead to confusion, loss of materials, and often to the use of the incorrect substances for a particular cleaning application.

During the experiment the following compounds were used for the outlined purposes:

*1. Cowles Chemical "Super Clean" for general purpose cleaning. It has a built-in yellow color that can be used to estimate the strength of concentrations being used.

*2. B.K. "Super Clorital" Pipe Line chlorinated cleaner with foamless qualities was used in the CIP circuits and storage tanks.

*3. Cowles Chemical "Complete", a detergent rich in caustic served as the detergent for circulation of the High Temperature Short Time unit. It avoided the use of acid treatment in the circulation process.

*4. Penn San "acid sanitizer" was used to sanitize the dairy equipment prior to product operations in the morning.

Reuse of Detergents

Information was sought to provide guidelines for the reuse of detergents for subsequent cleaning operations. In the cleaning of equipment, not all the detergent strength was spent. Discarded washing

---

*"Super Clean" and "Complete" was manufactured by Cowles Chemical Company, Cleveland, Ohio

Penn San was manufactured by B.K. Department, Pennwalt Chemical Corporation, Philadelphia, Pennsylvania

compounds could clean many more utensils before the material would have been entirely dissipated. If the detergents were to be saved, it was necessary to determine at what concentration the cleaning material should be saved to prevent growth of micro-organisms.

Raw milk and pasteurized milk were allowed to sour. A combined culture of the soured milks was used to seed various detergent concentrations in a laboratory experiment. Investigations showed an innoculum of seed as high as five percent in low detergent concentrations was still inhibited by the bactericidial effect of modern cleaning compounds. The results in Table 1 show that a 0.3 percent solution concentration by weight was effective in inhibiting bacterial growth. It would however be prudent for the processor to use a 3/4 to 1 percent concentration of detergent in the solutions when stored since this is about the concentration that would be needed for the next day's cleaning operations.

Quick Test for Detergent Concentration

A test was designed for ease of use in the processing plant. A similar procedure can be prepared for almost any plant and the detergent it uses. The reagents needed are phenophthalein indicator, a supply of one-tenth normal hydrochloric acid, a buret, a cup, and a titration curve. (See Figures 1 and 2)

Procedure

Five mls of the detergent sample were placed into a white porcelain dish and titrated with N/10 HCl using three drops of phenophthalein indicator. The titrating end point, red to colorless, was sharply

Reproduced from best available copy.

Table 1 ABILITY OF SOUR-MILK MICRO-ORGANISMS TO GROW IN DETERGENT SUBSTRATES (+ = growth, - = no growth)

Cowles Super-Clean

Percent Seed Additions	10%	5%	2.50%	1.25%	0.63%	0.31%	0.16%
Litmus Milk Results 24-48 hrs @ 35° C.							
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
6 day, 2,3,4 Weeks Incubation @ Room Temperature							
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
Nutrient Broth Results 24-48 hours @ 35° C.							
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
6 day, 2,3,4, Weeks Incubation @ Room Temperature							
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
Desoxycholate Agar Results 24-48 hours @ 35° C.							
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	+
5	-	-	-	-	-	-	+

Table 1 (Cont.) ABILITY OF SOUR-MILK MICRO-ORGANISMS TO GROW IN DETERGENT SUBSTRATES (+ = growth, - = no growth)

Cowles Super-Clean

Percent Seed Additions	10%	5%	2.50%	1.25%	0.63%	0.31%	0.16%
			6 Day @ Room Temperature				
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	+
5	-	-	-	-	-	-	+

Concentrations B.K. Clorital

Percent Seed Additions	10%	5%	2.50%	1.25%	0.63%	0.31%	0.16%
			Litmus Milk Results 24-48 hours @ 35° C.				
1	-	-	-	-	-	-	+
2	-	-	-	-	-	-	+
3	-	-	-	-	-	-	+
4	-	-	-	-	-	-	+
5	-	-	-	-	-	-	+
			6 Day, 2,3,4, Weeks Incubation @ Room Temperature				
1	-	-	-	-	-	-	+
2	-	-	-	-	-	-	+
3	-	-	-	-	-	-	+
4	-	-	-	-	-	-	+
5	-	-	-	-	-	-	+
			Nutrient Broth Results 24-48 hours @ 35° C.				
1	-	-	-	-	-	-	+
2	-	-	-	-	-	-	+
3	-	-	-	-	-	-	+
4	-	-	-	-	-	-	+
5	-	-	-	-	-	-	+

Table 1 (Cont.) ABILITY OF SOUR-MILK MICRO-ORGANISMS TO GROW IN DETERGENT SUBSTRATES (+ = growth, - = no growth)

Concentrations B.K. Clorital

Percent Seed Additions	10%	5%	2.50%	1.25%	0.63%	0.31%	0.16%
	6 Day, 2,3,4, Weeks Incubation @ Room Temperature						
1	-	-	-	-	-	-	+
2	-	-	-	-	-	-	+
3	-	-	-	-	-	-	+
4	-	-	-	-	-	-	+
5	-	-	-	-	-	-	+
	Desoxycholate Agar Results 24-48 hours @ 35° C.						
1	-	-	-	-	-	-	+
2	-	-	-	-	-	-	+
3	-	-	-	-	-	-	+
4	-	-	-	-	-	-	+
5	-	-	-	-	-	+	+
	6 Day @ Room Temperature						
1	-	-	-	-	-	-	+
2	-	-	-	-	-	-	+
3	-	-	-	-	-	-	+
4	-	-	-	-	-	-	+
5	-	-	-	-	-	+	+

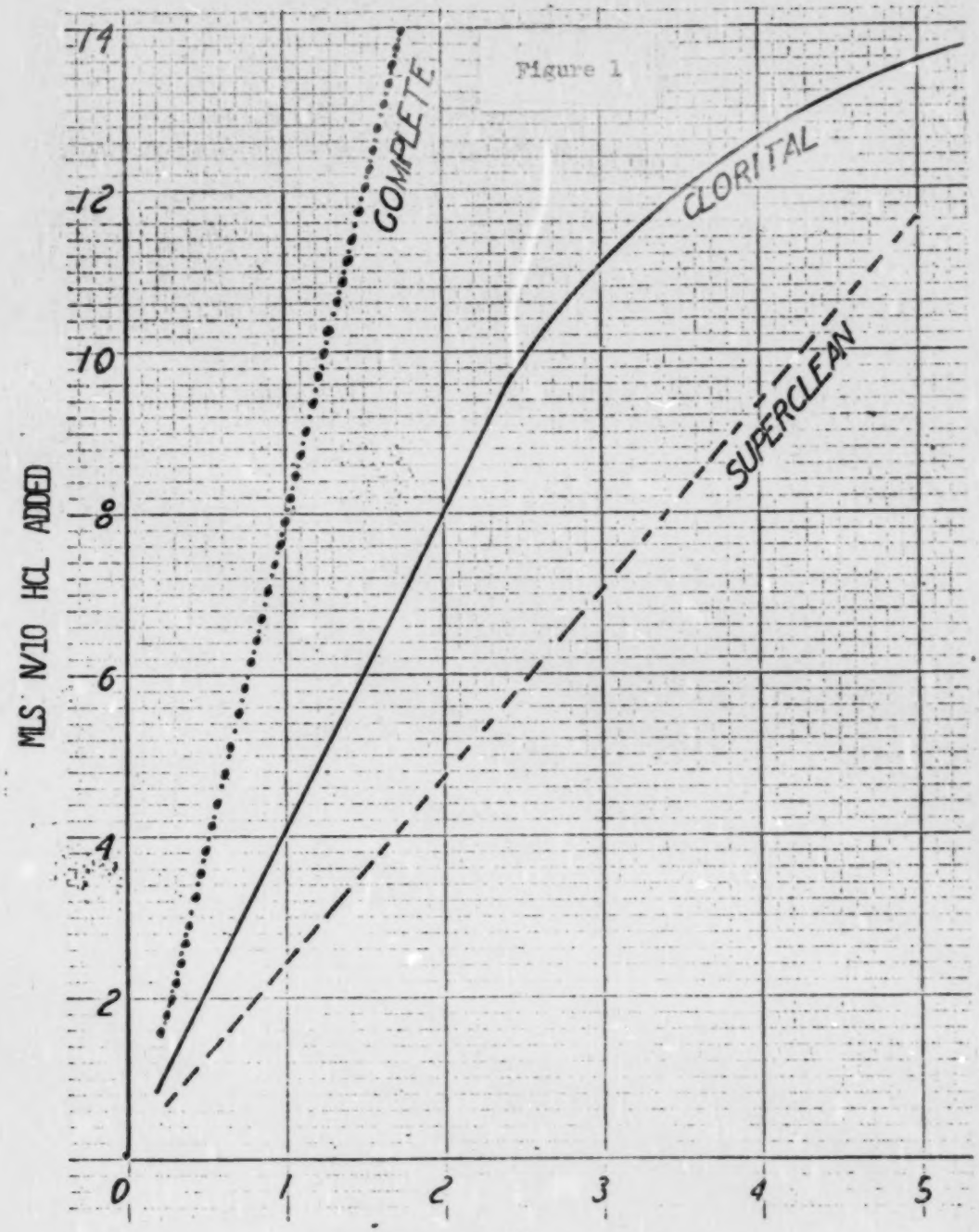
obtained. A plant worker would check the pre-made titration curve and would be able to read the apparent detergent concentration directly from the curve.

Each Detergent Must be Tested for Characteristics

When a cleaning compound is chosen by the plant purchasing agent a specific measureable usage characteristic should be found which can be tested for as an acceptable concentration index. The pH meter was not suitable for determining detergent intensity as pH results were not proportional to solution concentrations. For cleaning compounds used at this plant, the following characteristics were observed: In the anticipated operating range of the material a linear relationship of mls acid versus a percentage concentration by weight was found up to the three percent level. (See Figures 1 and 2)

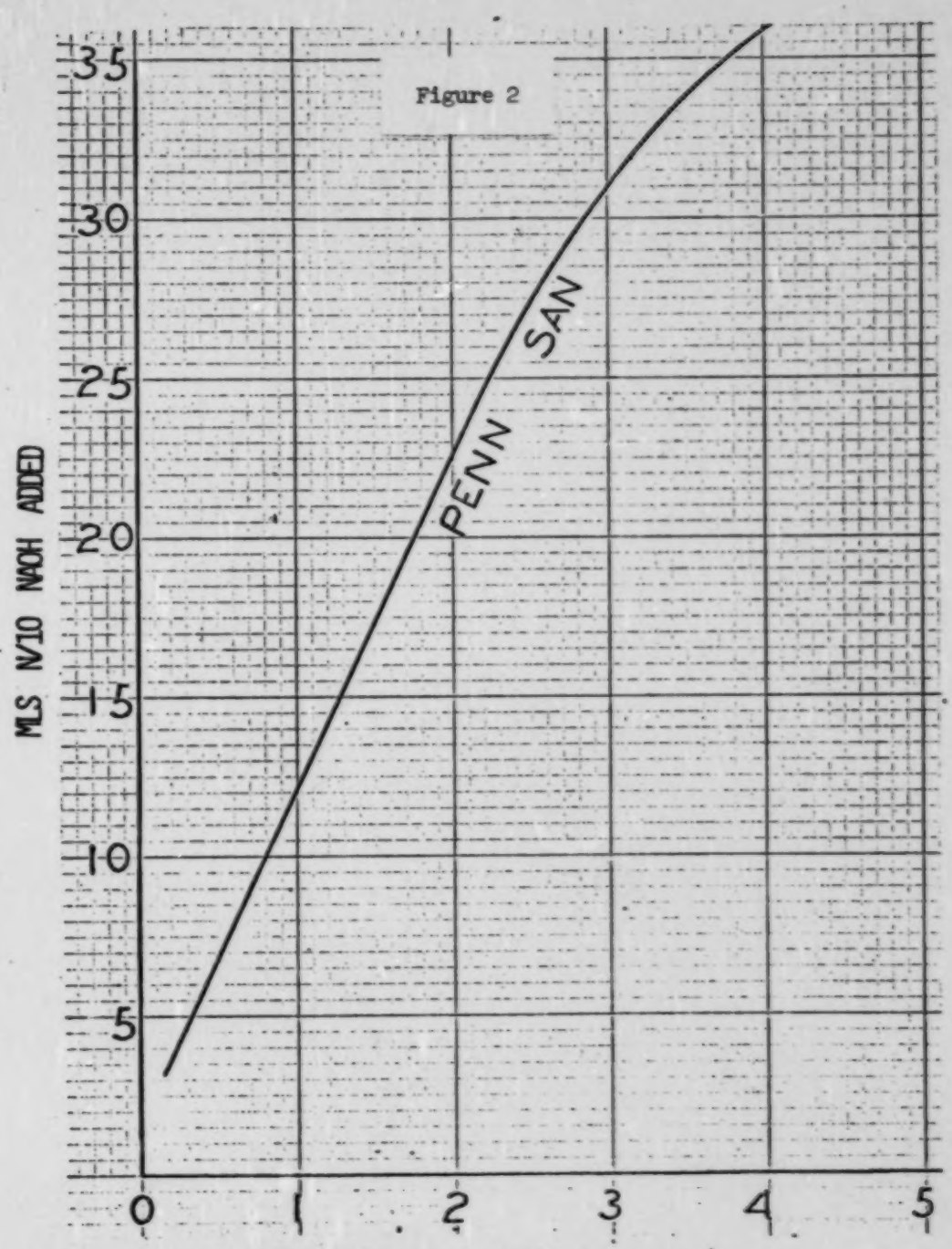
H.T.S.T. Circulation

Ten pounds of Cowles "Complete" was used with hot water to clean the pasteurizing plate equipment by circulation methods. A high pressure pump circulated the detergent through the system at a temperature of 185 degrees Fahrenheit for thirty minutes using a common re-circulation piping arrangement. The concentration of the detergent was 2.5 percent in a solution volume of approximately fifty gallons.



ACID REQUIRED TO TITRATE DETERGENT
TO PHENOPHTHALEIN END POINT

Figure 2



ALKALI REQUIRED TO TITRATE PENN SAN
TO PHENOPHTHALEIN END POINT

Segregation of Dairy Wastes for Recycling

Because milk is an excellent food for both man and micro-organisms, it is subjected to strict surveillance by health regulatory agencies. Milk plant operators normally use stringent safeguards to prevent accidental additions of water to milk through cleaning, rinsing, or other manipulations within the plant. Milk residuals left in storage tanks, over the road tankers, vats, pipelines, and other pieces of equipment usually are discharged as waste to the sewer system within the bottling plant.

Depending on the amount of piping and utensils required in the plant, or the degree of split flow within the operations, different amounts of inherent product losses will occur.

If managers are aware of the implications of correct line pitch and drainage and realize the product losses which can occur, they can take measures to salvage these materials for useful purposes within the plant.

Dilution

Methods should be developed within each dairy plant which allow the worker to segregate dairy product rinsings into storage vats so that volume, total solids, and fat concentration can be measured. Too liberal use of rinse water will dilute the salvage to a point where low product concentrations could make such a concept unattractive. It is vital that intelligent stop points be established and that the operator be provided methods of determining when the stop point has been reached. In regular systems with constant piping footage, rinsing for pre-

determined times can be a practical way to force residual milk products into a common salvage tank without excessive dilution.

Rinsings from the New York dairy plant were collected in forty-quart cans and tested for fat and total solids. The findings showed a nearly constant amount of waste existed regardless of the milk volume processed. The waste represented the holdup in the equipment at the end of the run. This is not influenced by the amount of material processed during the run.

Ice Cream Mix Waste

Waste rinsings of ice cream mix increased with the number of individual batches processed. The plant's policy of rinsing between each batch of ice cream mix to prevent mixing of different types of formulations was unique. Product waste would have been reduced by following one batch of ice cream mix with another without intermediate rinsing. The slight mixing of formulations that might result would be less objectionable in the investigator's opinion than the water adulteration that took place with the practice of intermediate rinsing.

Freezer Waste

Determinations were made on the plant BOD loading without including wastes from the ice cream freezing operation. This was done to pinpoint the percentage of BOD pounds contributed by the separate operations. Salvage of ice cream rinsings was difficult due to the presence of flavoring, nuts, and fruits. It was possible to strain the material and mask the flavor of the salvaged ice cream by incorporating the product into chocolate ice cream, however, the plant

personnel viewed this approach with disfavor.

Visual Determination of Dilution End Point

A common practice observed in the dairy industry is the visual determination of a dilution end point by the product's apparent color change. Often, a valve installed in the discharge line of a system is manually operated when a color change is first observed, thereby diverting diluted liquid to the floor. It is assumed that a plant worker can differentiate color changes quantitatively enough to distinquish normal milk from milk containing flushing water.

Series of dilutions were made up using milk, chocolate milk, white twelve percent ice cream mix, and twelve percent chocolate ice cream mix with varied amounts of water. One hundred percent products were mixed with equal volumes of plant water and these were halved a number of times to yield dilutions containing, on a volumetric basis; 100%, 50%, 25%, 12.5% and 6.25% of product.

Neither the investigator nor a number of his colleagues could visually differentiate the dilutions between 25% to 6.25%. The lower three dilutions appeared to be the same milk product, although they were lighter in color than the 100% and 50% samples. No difference was observed in the four previously mentioned dairy products when an undiluted material was compared with its 50% dilution. Those individuals claiming they can determine an end point effectively by eyesight would seem to be incorrect based upon these experimental trials.

Other Testing Guidelines

A product control laboratory could determine quantitative differences in diluted samples by many methods. The use of total solids by

Reproduced from best available copy.

dehydration techniques could be employed to measure dilution changes in solids. The freezing point of the dilutions could be used to indicate quantitative differences when compared with undiluted samples. In this investigation a quick method was sought that would provide dilution information under practical plant conditions which effectively segregated dairy products. As previously discussed, time measurements could be effective with constant amounts of piping and uniform pumping rates. The dairy plant personnel could sample individual circuits which remain constant in their operation and assign a time period to them for flushing dairy products. Management could also determine the additional rinsing time required to obtain salvageable products. After that time, rinsings can be diverted to the sewer.

By using a clock timer of sufficient size to be easily seen, and equipping it with a mechanism to activate a horn or buzzer, the plant operator could protect his product from adulteration plus salvage valuable material for reprocessing.

Table 2 is presented to show data obtained by use of a Solu-Bridge Model RD-4 instrument to measure conductivity in a series of water diluted milk, chocolate milk, white ice cream mix, and chocolate ice cream mix. These results should not be compared with conductivity reading in Table 10 because in both experiments temperature corrections were not made. The products were examined to determine only whether or not the Solu-Bridge instrument would give conductivity readings and to what degree of sensitivity in the product with water dilutions.

Most electrolytes have conductivity-temperature coefficients between two and three percent per degree Centigrade over the range 0-100 degree Centigrade, the conductance rising with rise of temperature.

The scale on the Model 4 Solu-Bridge used in the experiment was calibrated to read from 0 to 500 grains per gallon NaCl, with a Model 9 cell. The numerical readings, per se, have no specific meaning in the experiment since it did not involve NaCl solutions. Most Solu-Bridge ranges can be changed by utilizing a cell of higher or lower cell constant than is required to match the bridge scale.

Specific conductance is inversely proportional to electrical resistance. Inorganic compounds in solution dissociate into ions which will conduct electricity in proportion to the concentration of ions present. The conductivity test, therefore, is not specific for any one ion.

Table 2 USE OF SOLU-BRIDGE MODEL RD-4 INDUSTRIAL INSTRUMENT
(Calibrated in grains/gallon NaCl 0-500)

Concentration	White Milk	Chocolate Milk	12% White Ice Cream Mix	12% Chocolate Ice Cream Mix
100%	175	250	95	105*
50%	112	150	85	140
25%	75	90	55	85
12.5%	42	60	30	45
6.25%	30	35	22	32

*Rechecked results were similar
Dilution was made on a volumetric basis with tap water.

The results of the experiment suggested the possible application of the Solu-Bridge instrument, measuring conductivity, as a tool to measure the degrees of dilution. An in-plant experiment was carried out in which samples of the water used to rinse the equipment after the processing of white milk and chocolate milk were taken at five second intervals from the discharge line of the High Temperature Short Time pasteurizer. The samples were tested for conductivity using the Solu-Bridge, total solids using a Mojonnier Tester, and an IRMA*. for fat, protein, and lactose. The results are presented in Table 3.

Limitations of the Mojonnier test equipment, plus inherent errors of the analyst, cast doubt on results below a one-half percent solids. As indicated in the Table, the IRMA tester did not function properly on samples of chocolate milk, nor was it able to show changes in the total solids of white milk rinsings taken after two minutes thirty seconds (Sample 9). Also these samples were too dilute to be tested by the Mojonnier method. The Solu-Bridge readings, however, did show changes in conductivity for an additional forty-five seconds of dilution.

Figures 3 and 4, in which the same results are presented in graphical form, seem to suggest the possible use of conductivity as an index of dilution of dairy products with water in the rinse operation. The erratic behavior of the chocolate milk at the beginning of rinsing is apparently due to the difficulty in flushing this product. Chocolate rinse problems were probably due to the viscosity of chocolate milk caused by sugar, chocolate, and stabilizers. Chocolate milk was also pasteurized fifteen degrees higher than white milk in the High

---

*IRMA means infra red milk analyzer. The apparatus is manufactured by the Grub Parsons Limited of Nird, England.

Table 3 COMPOSITION OF SAMPLES OBTAINED AT FIVE SECOND INTERVALS AFTER THE START OF RINSING

Sample No.	Product	Time	Solu-Bridge Reading	IRMA Reading			Addition of IRMA	Mojonnier Total Solid
				Fat	Protein	Lactose		
1	Milk	2 Min. 50 Sec.	200.0	2.38	2.30	2.59	7.27	7.33
2	"	" " 55 "	180.0	2.10	1.91	1.90	5.91	5.63
3	"	3 " 0 "	120.0	1.69	1.50	1.08	4.21	3.45
4	"	" " 05 "	90.0	1.31	1.15	0.49	2.95	2.60
5	"	" " 10 "	30.0	1.08	0.91	0.09	2.08	1.69
6	"	" " 15 "	22.5	0.87	0.79	0	1.68	0.95
7	"	" " 20 "	18.0	0.76	0.70	0	1.46	0.72
8	"	" " 25 "	16.0	0.69	0.62	0	1.32	0.45
9	"	" " 30 "	14.0	0.68	0.60	0	1.28	-
10	"	" " 35 "	13.0	0.61	0.58	0	1.19	-
11	"	" " 40 "	12.5	0.60	0.58	0	1.18	-
12	"	" " 45 "	11.5	0.59	0.58	0	1.17	-
13	"	" " 50 "	11.0	0.59	0.58	0	1.17	-
14	"	" " 55 "	10.5	0.59	0.58	0	1.17	-
15	"	4 Min 0 Sec.	10.0	0.58	0.58	0	1.16	-
16	"	" " 05 "	10.0	0.58	0.58	0	1.16	-
17	"	" " 10 "	9.5	0.58	0.58	0	1.16	-

Table 3 (Cont.) COMPOSITION OF SAMPLES OBTAINED AT FIVE SECOND INTERVALS AFTER THE START OF RINSING

Sample No.	Product	Time	Solu-Bridge Reading	IRMA Reading			Addition of Irma	Mojonnier Total Solid
				Fat	Protein	Lactose		
18	Chocolate M.	2 Min. 0 Sec.	140.0	2.83	2.73	9.00	14.56	16.41
19	"	" " 05 "	135.0	3.05	3.07	10.00	16.12	17.03
20	"	" " 10 "	135.0	3.02	3.04	10.00	16.06	17.33
21	"	" " 15 "	135.0	IRMA equipment was not able to function properly with chocolate milk due to plugging of the passages. Scatter of readings was obtained with cleaning.				16.75
22	"	" " 20 "	135.0					17.11
23	"	" " 25 "	120.0					16.77
24	"	" " 30 "	120.0					16.87
25	"	" " 35 "	125.0					14.92
26	"	" " 40 "	120.0					13.27
27	"	" " 45 "	95.0					9.04
28	"	" " 50 "	65.0	1.20	1.65	3.23	6.08	5.30
29	"	" " 55 "	45.0					2.99
30	"	3 Min. 0 Sec.	33.0					1.97
31	"	" " 05 "	25.0					1.34
32	"	" " 10 "	22.5					-
33	"	" " 15 "	20.0	0.78	0.16	0.24	1.18	-

Temperature Short Time plate equipment and with this elevated temperature greater product-to-plate adherence would occur.

Table 4 shows the conductivity of water solutions or suspensions of sucrose, lactose, chocolate, and butterfat.

Table 4 CONDUCTIVITY OF WATER SOLUTIONS OR SUSPENSIONS OF SOME COMMON COMPONENTS OF DAIRY BY-PRODUCTS USING SOLU-BRIDGE RD-4

	Solu-Bridge Scale Reading			
Concentration	Cocoa	Sucrose	Lactose	Partially Refined Butteroil
Percent by weight				
10.0	*	6.5	29.0	16.0
5.0	150.0	6.0	20.0	15.0
2.5	90.0	6.0	13.0	12.5
1.3	50.0	6.0	10.0	12.0
.63	27.5	6.0	8.0	12.0
.31	16.0	6.0	7.5	12.0
.16	10.5	6.5	7.5	12.0
.08	8.0	6.0	7.5	10.5
.04	7.0	6.0	7.0	10.5

*off scale

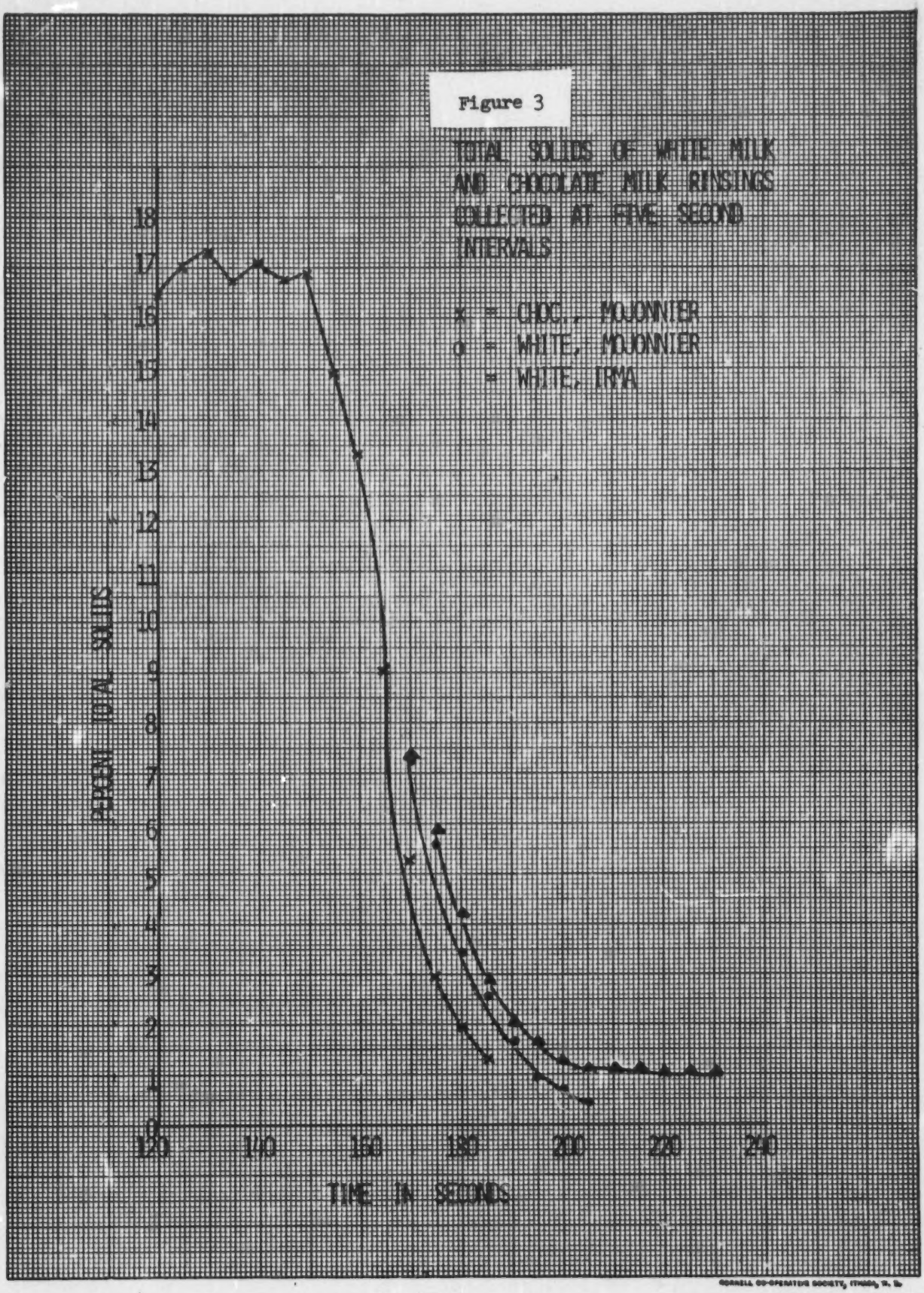


Figure 3
TOTAL SOLIDS OF WHITE MILK AND CHOCOLATE MILK RINSINGS COLLECTED AT FIVE SECOND INTERVALS
x = CHOC., MOUNNIER
o = WHITE, MOUNNIER
= WHITE, IRMA
PERCENT TOTAL SOLIDS
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
120
140
160
180
200
220
240
TIME IN SECONDS

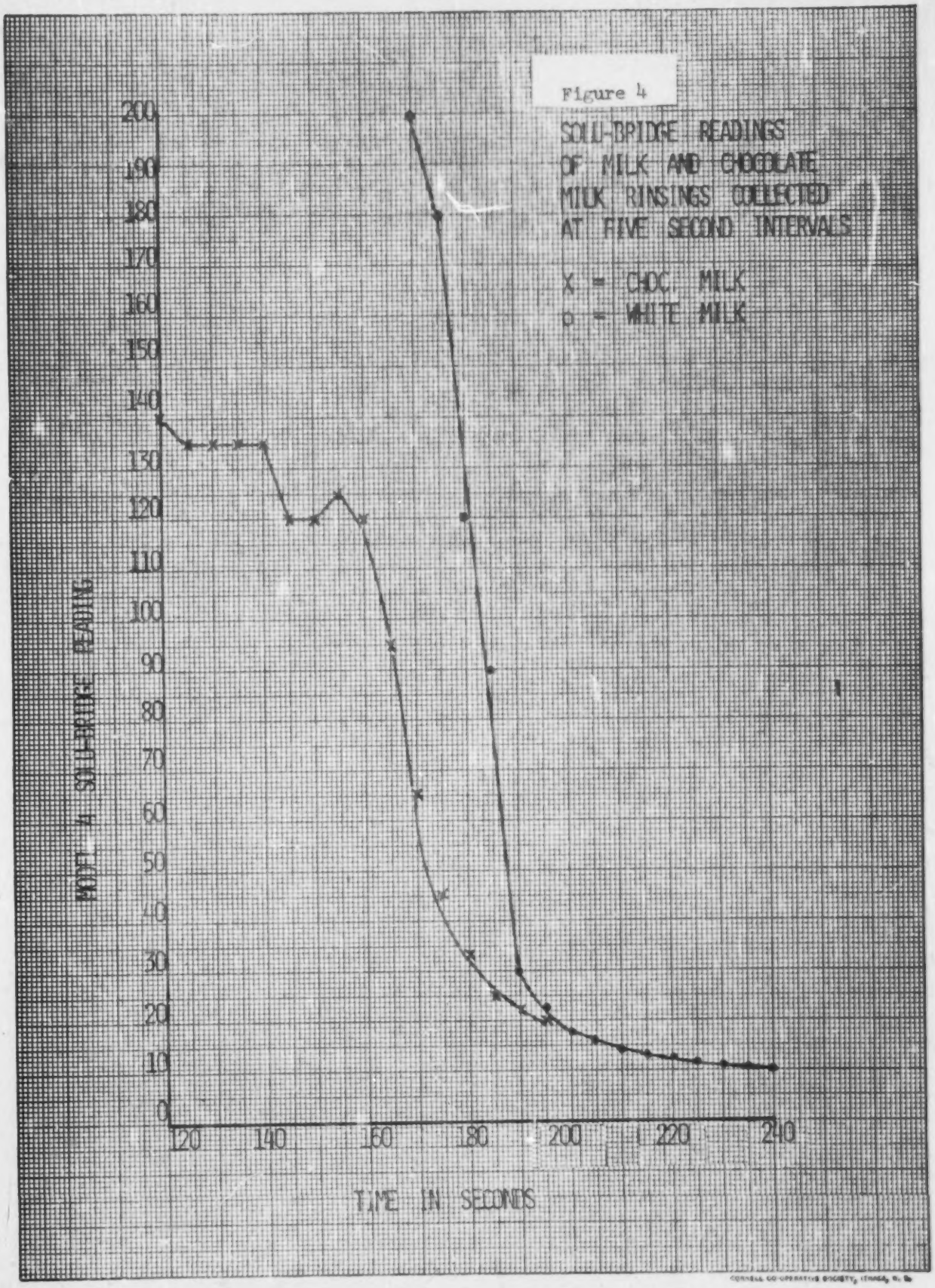


Figure 4
SOLU-BRIDGE READINGS OF MILK AND CHOCOLATE MILK RINSINGS COLLECTED AT FIVE SECOND INTERVALS
X = CHOC. MILK
o = WHITE MILK
MOFF # SOLU-BRIDGE READING
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
120
140
160
180
200
220
240
TIME IN SECONDS

RESULTS AND MEANING

Waste Dilution

Frequently large volumes of waste result from the "no care" attitude of the plant worker and his supervisor. The direct effects of carlessness increase the use of water which will become increasingly more valuable with the passage of time. When waste waters from a food plant are hot it usually indicates that fuel has been wasted. In addition, heated waste can create operational problems in the sewage disposal system by decreasing oxygen retention of the fluid.

Very little can be done by any plant management once waste has entered a common sewer. Managers, not realizing the importance of volume reduction, complicate waste handling problems. Evaluating dairy plant practices along waste prevention lines can be utilized to minimize waste volumes.

Monitoring Information

Unless the specific site's staff was complying with regulatory agency's request to gather waste information, management fails to regard waste effluent information as a tool to aid plant operation. When personnel are routinely aware of the volume of waste material being discharged from the plant, they have an incentive to reduce the amount of water being used. Regularity in operations or uniformity of actions can be checked by collecting a running account of the plant's waste characteristics.

Strip chart records of the simplest data can be an effective tool in the hands of the imaginative supervisor. Each plant produces "finger print" like patterns that trace starts and stops of operations within the plant. Irregularities can be promptly noted and often corrective measures can be taken to enhance the plant operation.

Volume Reduction

The initial waste effluent survey of the New York dairy plant indicated discharge volume flows as follows:

October 2, 1967	12,290 gallons
October 13, 1967	10,393 gallons
October 16, 1967	11,415 gallons
October 23, 1967	9,800 gallons
October 25, 1967	14,200 gallons

Following a waste minimization educational program designed to improve the plant worker's processing technique, the results listed below were obtained:

November 8, 1967	6,299 gallons
November 10, 1967	6,364 gallons
November 13, 1967	5,156 gallons

The data indicated a fifty percent reduction in waste discharge volume was achieved without making changes in the physical equipment of the plant. Figures 8, 9, and 10 illustrate graphically the results that were achieved by reducing careless handling of water in the dairy plant. Personnel will have to be constantly motivated and reminded to continue waste minimization programs to prevent reoccurrence of the October waste volume amounts. It appears reasonable that monitoring recording devices be capable of showing daily waste effluent patterns. The plant workers will then be aware that carelessness on their part can be recognized by their supervisors.

More Reduction can be Achieved

By no means has the waste reduction been fully exploited in the investigation. Modifications in plumbing to convey water directly to places of use and the use of economy valves will further reduce the best water use obtained in the experiment. Plants having a supply of only cold water and steam cannot use the "economy valves*" because of safety reasons. Such plants can invest modest sums of money to install separate steam water heaters in centralized sections of the plant to give the worker three types of water. The common dairy plant hose station should be plumbed to mix cold and hot water and have a separate hose only for steam needs.

Temperature Reduction

Figures 5 through 10 illustrate the fluctuations in waste water temperatures before and after recognition of the waste problem by the plant personnel. Along with reductions of temperature lobes caused by incorrect operation of equipment, a possible added benefit was achieved by lowering the average waste discharge temperatures. The high volume flows existing before changes were made reached average temperatures of 100 to 105 degree Fahrenheit. With minor changes in

*Economy valve refers to a device that automatically shuts off when the valve is released.

the operations it was possible to reduce the flow rate and also to reduce the average temperature by twenty degrees. Climatic conditions caused changes in the raw water temperature during the course of the experiment. The October temperature was 53 degrees Fahrenheit, while November raw water was 47 degrees Fahrenheit. Reduced water temperature aided the drop in temperature of the effluent, but the primary cause was obviously the diminishing of waste hot water diverted to the sewer system by the plant workers.

Decrease of Btu to Sewers

Figures 5 through 10 show the pounds of waste and temperature of wastes above incoming raw water temperature as a function of time of day. Plots were made at five minute intervals over a twenty-four hour day.

The most significant portion of the graph was the operating hours when plant management was able to take appropriate measures to improve the waste discharge profile. Flows of cooling water vital for refrigeration condensers will often be discharged to the common sewer unless water economizers, recycling the coolant, are employed by the plant. The New York dairy does utilize economizers, but elects to discharge a minor portion of the water from the ice cream freezer compressors to the sewer. This shows on the charts as a fairly constant, low volume flow during the hours when the plant is not operating.

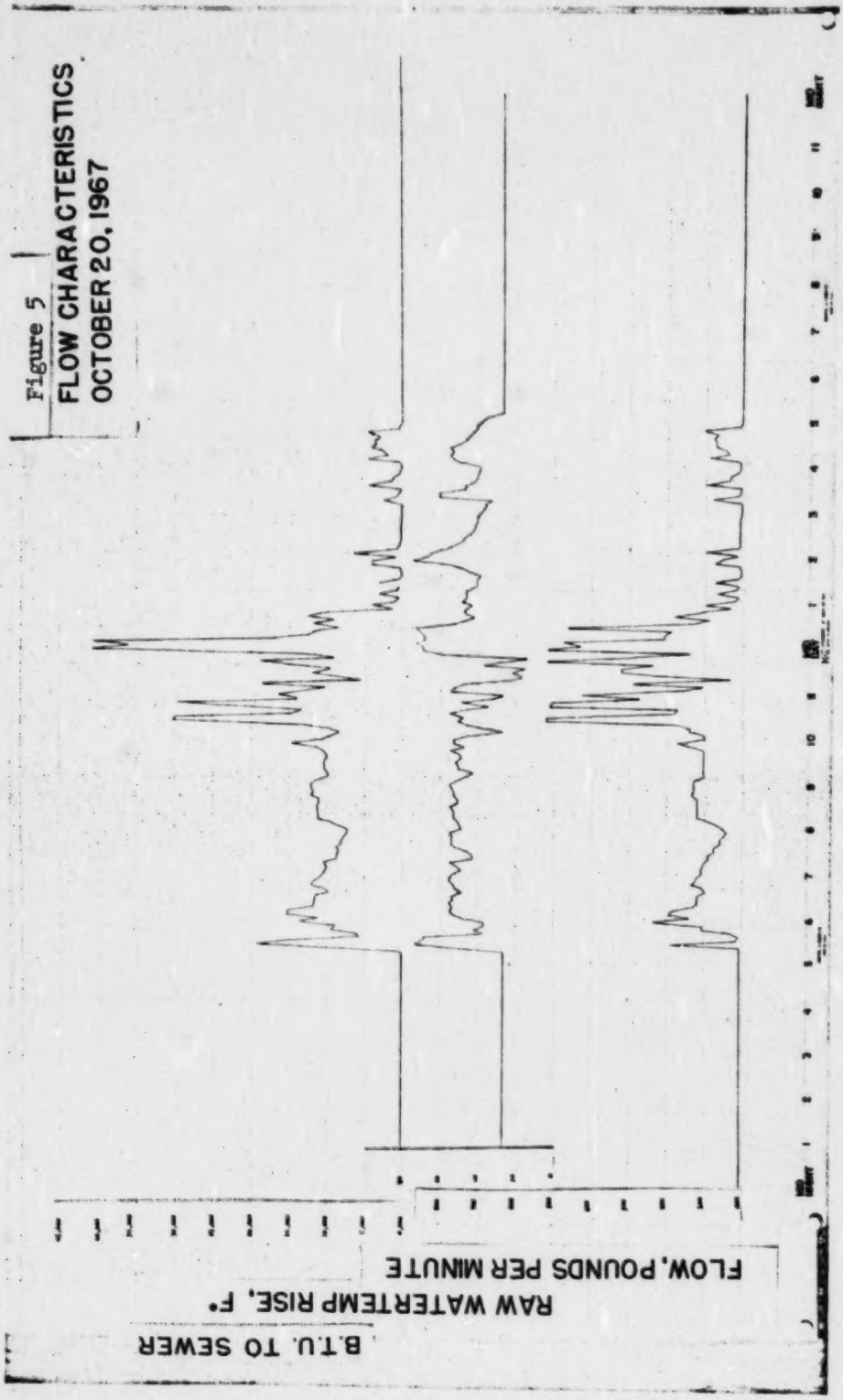


Figure 5
FLOW CHARACTERISTICS
OCTOBER 20, 1967

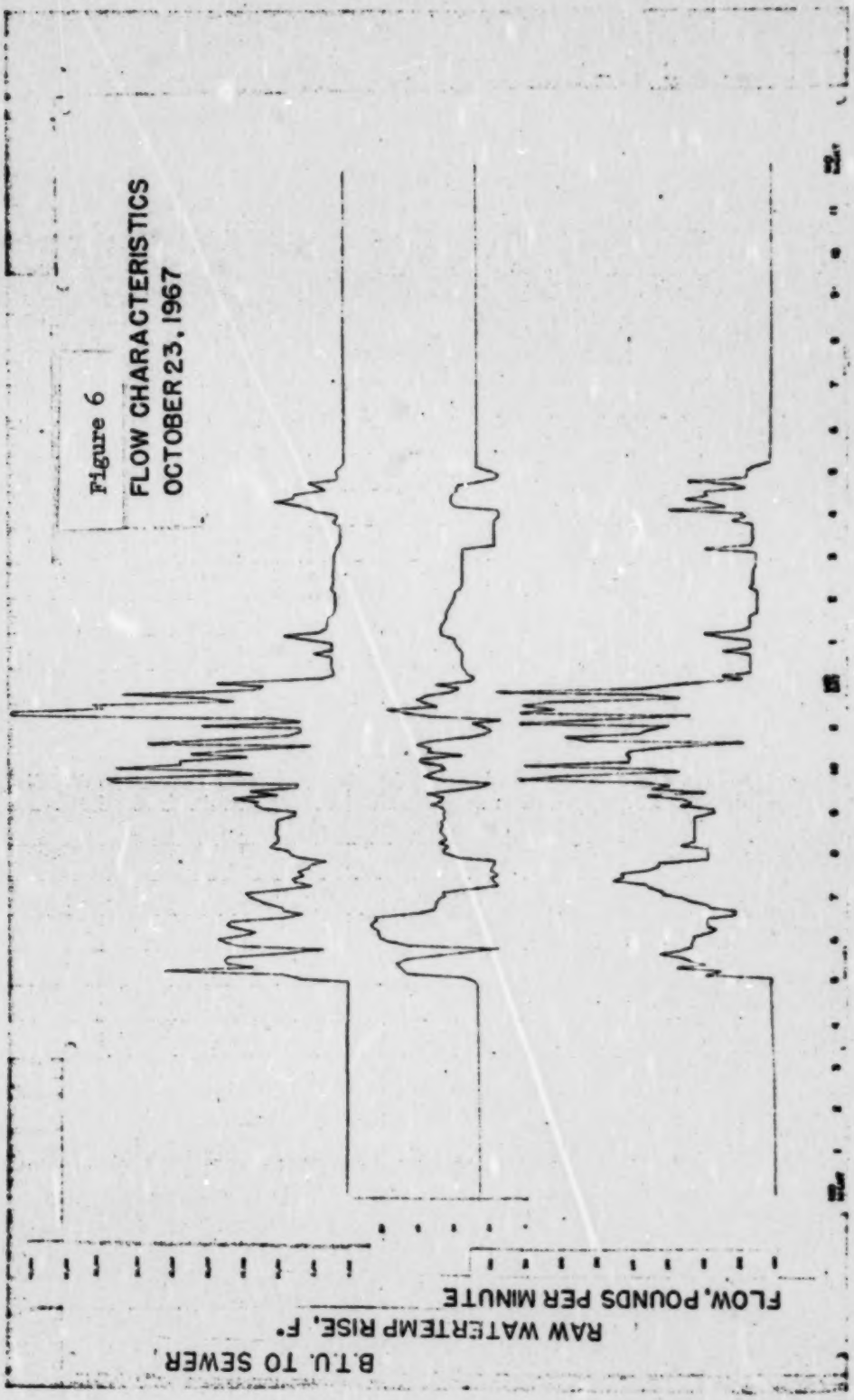


Figure 6
FLOW CHARACTERISTICS
OCTOBER 23, 1967
B.T.U. TO SEWER
RAW WATERTEMP RISE, F°
FLOW, POUNDS PER MINUTE

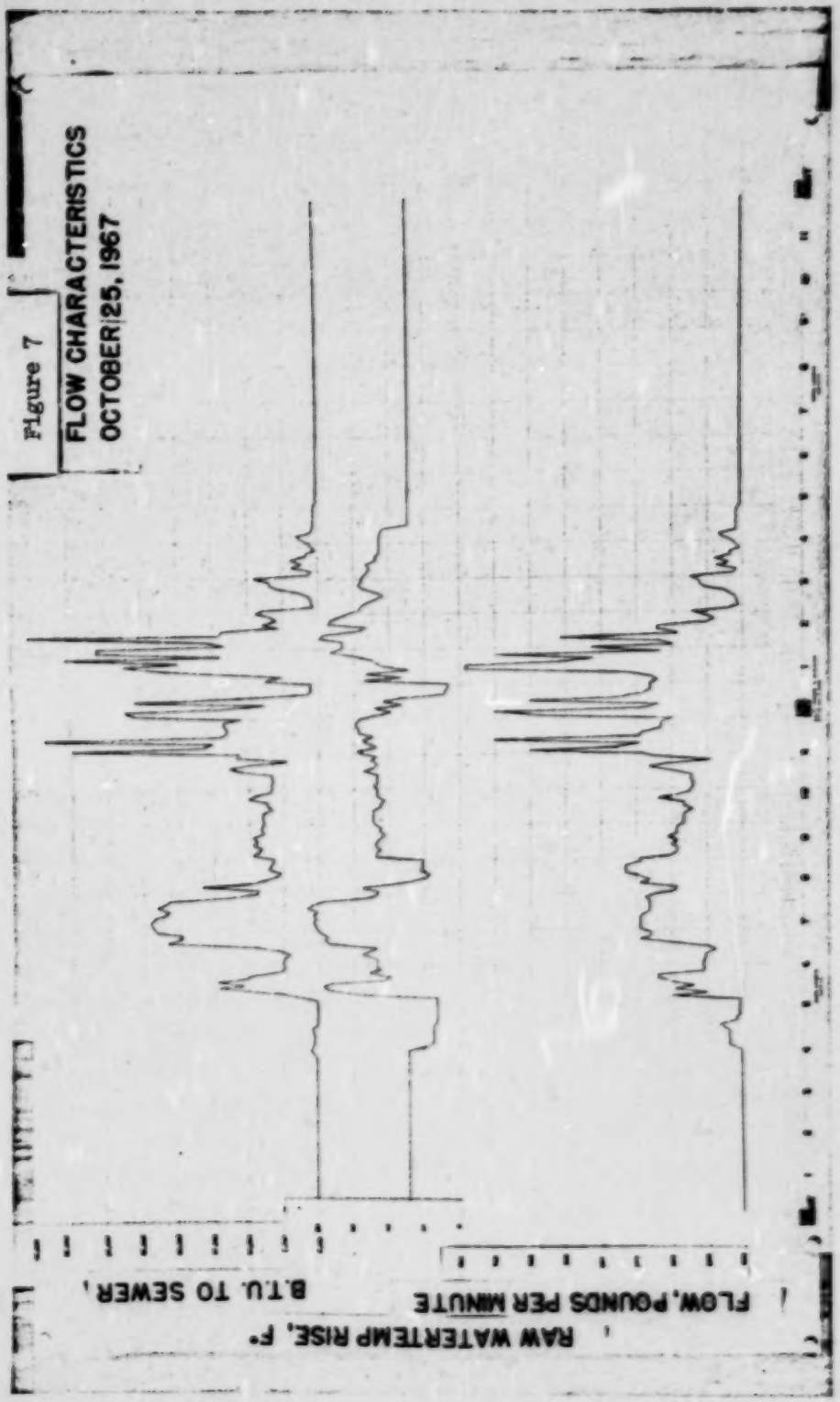
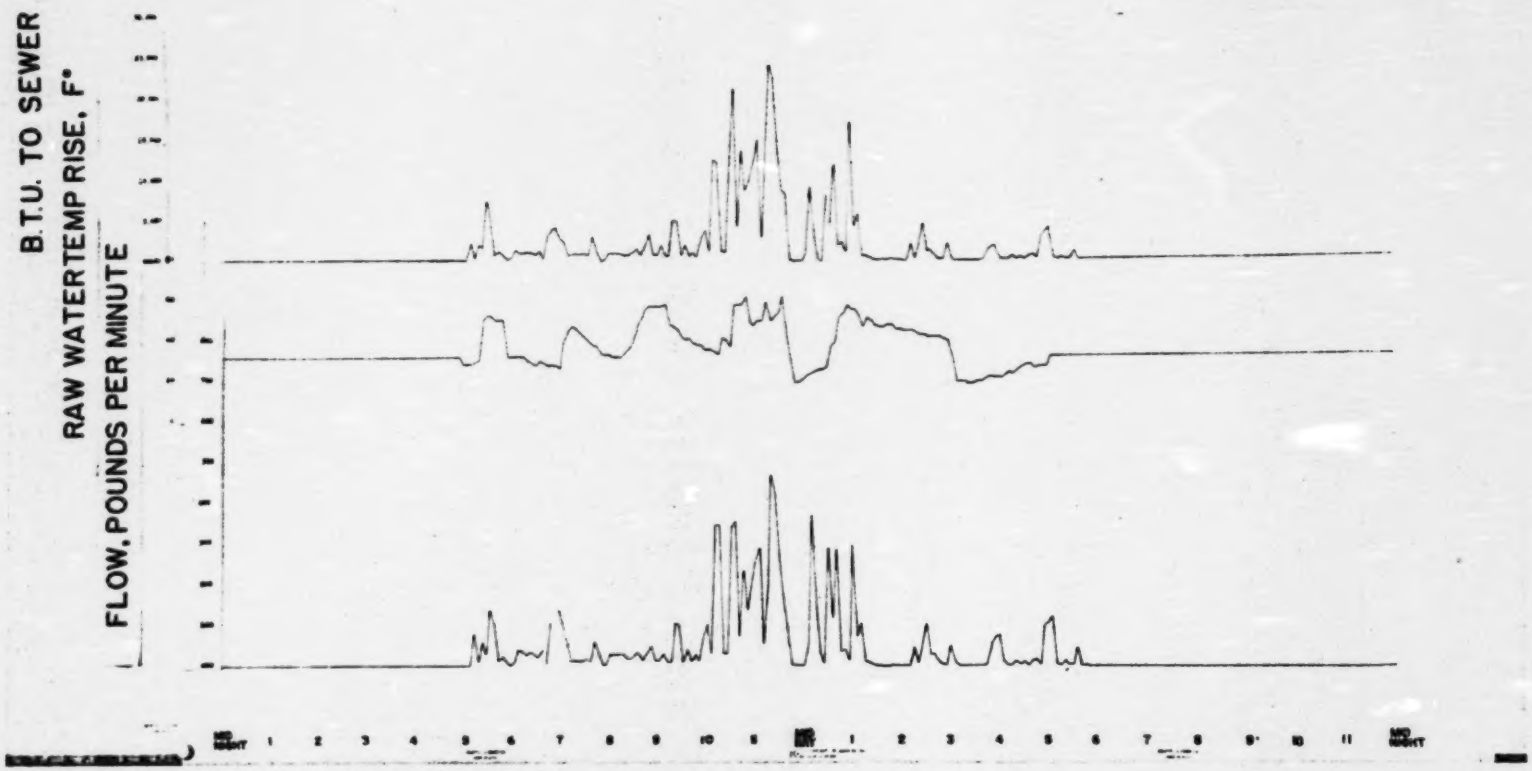


Figure 7
FLOW CHARACTERISTICS
OCTOBER 25, 1967
RAW WATERTEMP RISE, F°
B.T.U. TO SEWER,
FLOW, POUNDS PER MINUTE

Figure 8
FLOW CHARACTERISTICS
NOVEMBER 8, 1967



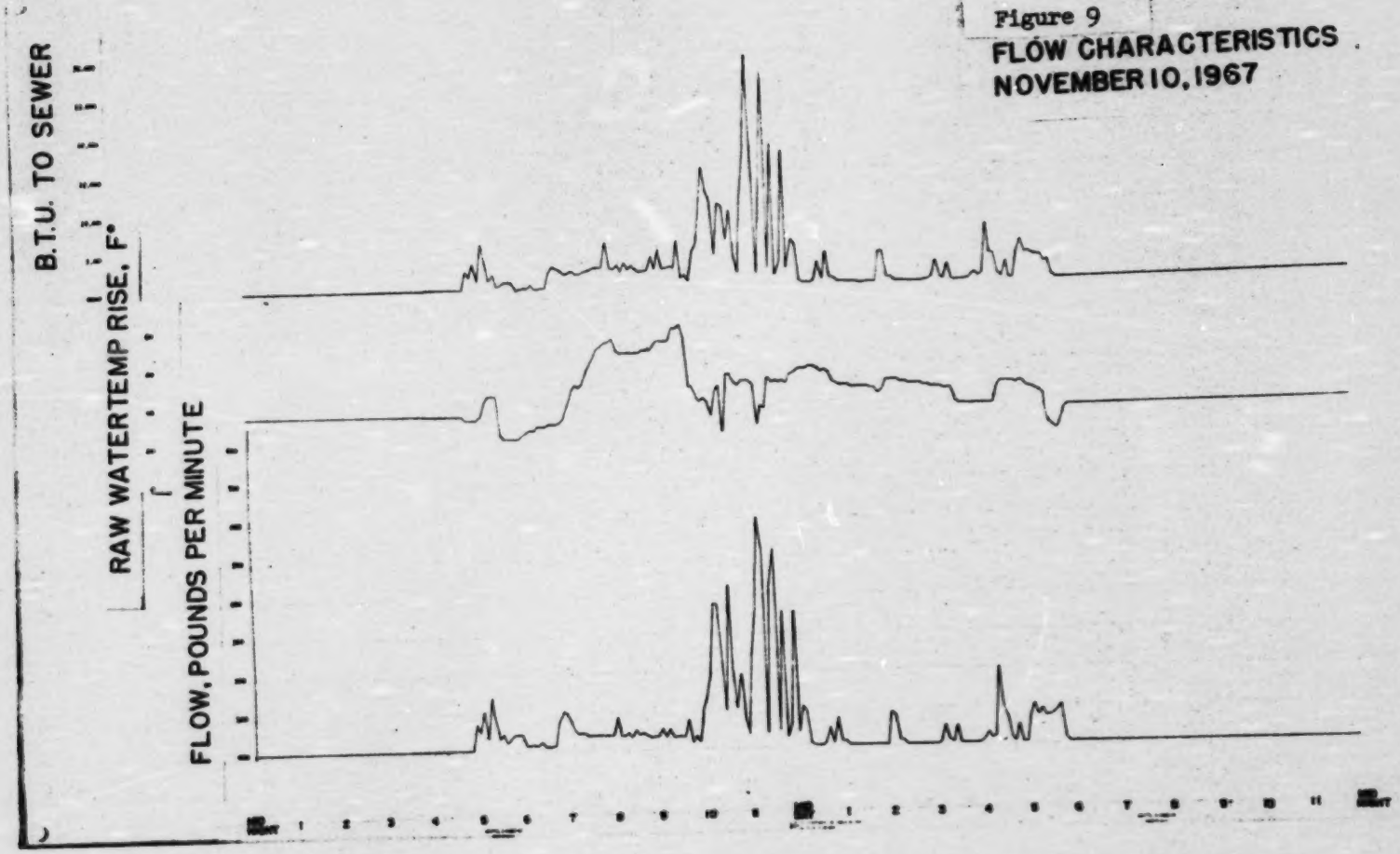
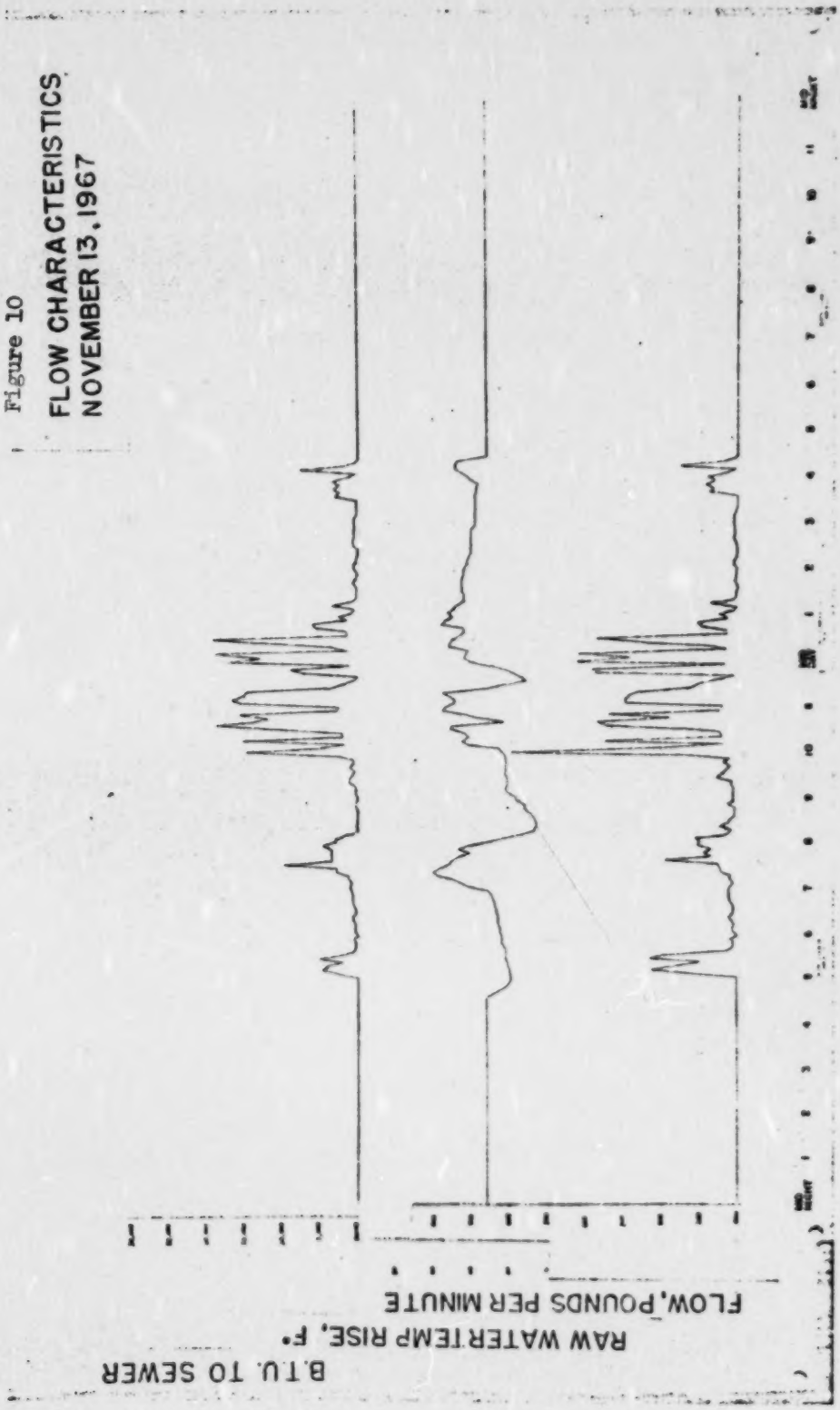


Figure 9
FLOW CHARACTERISTICS
NOVEMBER 10, 1967

Figure 10

FLOW CHARACTERISTICS
NOVEMBER 13, 1967



The average rate at which Btu's were discharged to the sewer during operating hours was calculated for each day's operation. The results on selected days were:

October 23	9,499 Btu/min	Normal operation with
October 25	13,106 Btu/min	no waste segregation
November 8	2,901 Btu/min	Modified operating
November 13	3,168 Btu/min	practices

The results indicate that a four to one reduction was achieved.

Fuel Economy

Reduced hot water consumption, of course, reduces fuel use. Too few plants have steam flow meters in the central power plant, let alone individual steam flow meters at major pieces of equipment. Without measuring devices managers can only guess at the amount of steam used at individual pieces of equipment. If a steam flow meter is available in the central power plant, the instrument can be used to measure individual uses by stopping and starting various equipment. On a simpler scale it was found that recording the temperature of waste can help to isolate causes of fuel waste in the plant.

Temperature Relationship

Temperature recording charts indicate differences in operations by the plant. To use this approach, temperature records have to be obtained on a number of successive days. For each site sufficient preliminary data may be collected to scan the plant operation. Comparisons of the charts will begin to indicate characteristic operations. Swings in degrees can be traced back to specific operations.

In the investigation a lobe (see Figure 11) was noted in which the temperature rose to 150 degrees in the outfall pipe. The unusual temperature rise was found to be caused by improper use of a ten-can cream pasteurizing vat. With simple adjustments of the steam and water valves, it was possible to completely eliminate the lobe, as shown in Figure 12, thus reducing steam waste and water usage. In addition, the jagged erratic temperature chart was formed in Figure 11 when waste volume was high because of careless water use. With the police action of the researcher one notes a smoothing out of peaks and valleys with creation of a more uniform temperature chart for the day's operation. (See Figure 12)

For different operating conditions at different sites a reverse type chart could, perhaps, indicate a better operation. Therefore, although the chart contains valuable information, the individual plant must learn to interpret the data properly.

Waste Segregation Value

Aside from the immediate increase in product recovery when waste segregation is practiced, one gains many related advantages. Personnel will become more receptive to ideas that will result in economics for a plant when they are not allowed to dispose of plant products to the sewer. Successful plant managers have gone to the extreme of actually insisting on special detailed handling of products that could not return a profit to the firm because of high labor costs. They explained the action by noting that if waste was tolerated by the supervisor, more waste was contributed by the employees.

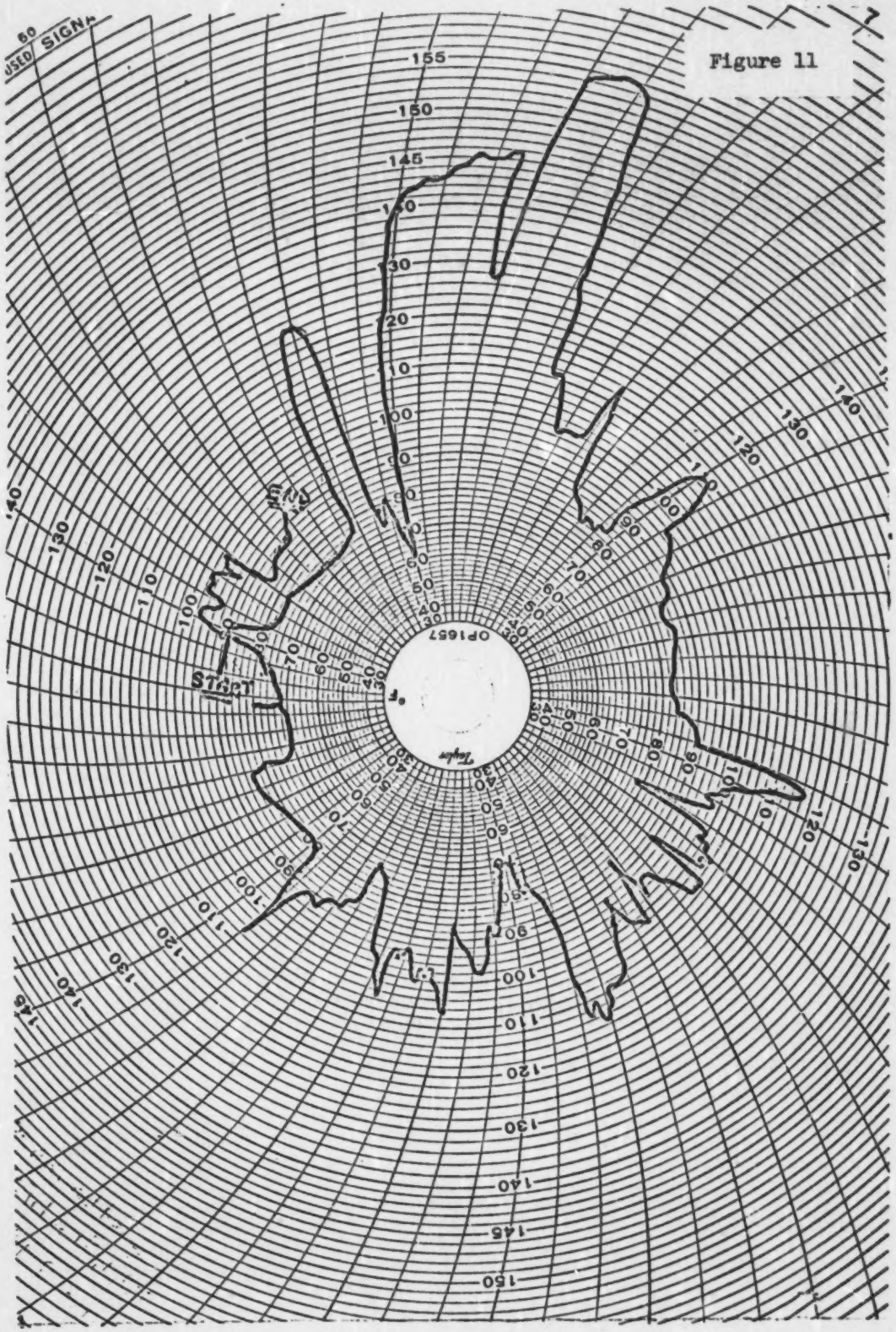


Figure 11

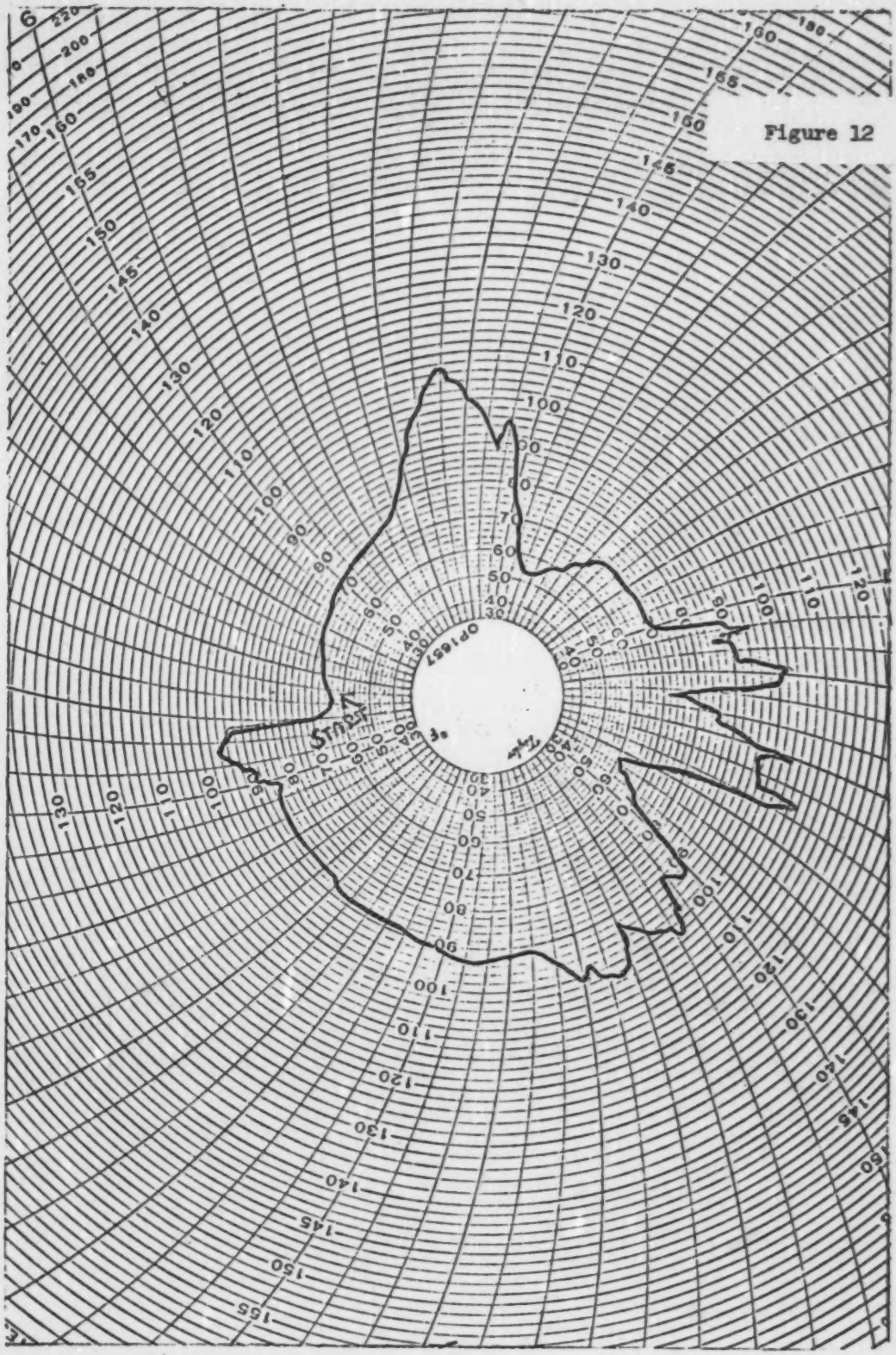


Figure 12

If the firm must handle plant wastes by private means, a reduced waste load will reduce the waste handling costs for the firm. Both the operating and construction costs for a waste system are lower when waste segregation is practiced. Firms discharging waste to municipal systems using a fee charge based on loading or volume will also achieve a lower waste handling cost.

Results of BOD tests on representative waste composites were as follows:

Date	BOD
October 2, 1967	320
October 13, 1967	400
October 16, 1967	1200
October 23, 1967	475
October 25, 1967	520
November 8, 1967	500
November 10,1967	1200
November 13,1967	630

These figures were quite meaningless unless they were coupled with additional information indicating the volume of the waste. A high BOD figure with a low volume could have indicated less plant waste than a low BOD value coupled with a very high total volume of waste. In other words, the product of BOD and total flow is the real measure of waste. Neither value alone provides sufficient information. Intensive information ratherthan extensive values can be misleading to the plant operator. Plants have been known to deliberately dilute wastes in an operation if they were aware that regulatory personnel were sampling the plant's waste effluents. If the monitoring of the wastes was confined to mere grab samples of the effluent, then dilution makes the load appear smaller for obvious reasons. Surely, nothing has been achieved by diluting flow rates from the site as it merely complicated the design requirements of the waste handling system.

Reduction in Pounds of BOD

Rinsings from the lines and tanks were segregated as white or chocolate rinsings. Removal of such material reduced the pounds of BOD in the effluent as follows:

Date	Pounds of BOD in Waste (No Segregation)
October 23, 1967	38.79
October 25, 1967	61.54
November 10, 1967	63.65

Date	Pounds of BOD in Waste (With Segregation)
November 8, 1967	26.26 (combined bottling and ice cream freeze)
	21.00 (freezing wastes removed from effluent)
November 13, 1967	32.48

The weights and composition of rinsings saved are listed in Table 5.

Table 5 SALVAGED DAIRY PRODUCTS RINSINGS

Date	Weight lbs.	Type	Composition % Fat	% S.N.F.
10/30/67	688	White & Chocolate	1.4	6.20
10/31/67	396	White	3.1	8.18
10/31/67	182	Chocolate	5.6	16.51
11/7 /67	440	White	4.6	9.98
11/8 /67	180	Chocolate	2.2	8.00
11/8 /67	322	White	2.2	6.98
11/13/67	430	White & Chocolate	2.0	7.02

Four different types of salvaged dairy material were collected. Bottling operations contributed white and chocolate rinsing with approximately two percent fat and about seven percent total solids. Approximately ten pounds of fat and twenty-five pounds of S.N.F. were salvaged in the rinsings collected during the course of a days pasteurizing and bottling operation. On days when ice cream mix was made, about twenty pounds of fat and fifty pounds of solids non-fat were salvaged for reuse. A weekly accumulation of rinsings yielded approximately fifty pounds of fat and one hundred twenty-five pounds of solids non-fat.

Although BOD values are an index of waste concentration, the results of a BOD test are not available until after five days of incubation of a sample. It was shown that conductivity measurements could be used to immediately pick up massive doses of product loss. However, the method would miss low concentration losses. PH monitoring was explored to see if it could serve as a measure of dairy waste concentration.

Table 6 gives the pH of the effluent at half hour intervals. Data suggested that monitoring did show additions of alkaline or acid material, but did not differentiate between varied concentrations of milk waste being discharged. It was noted that even highly colored white effluents or rich chocolate waste had nearly the same pH.

A laboratory experiment was carried out to determine the relationship between concentration of dairy products in dilute solutions and pH. Using four common dairy products as the test media, the following data were obtained.

Table 6 EFFLUENT pH

Time	October 2, 1967	October 23, 1967	October 25, 1967
5:01	7.2	7.3	7.8
5:31	4.5**	8.2	3.3*
6:01	7.6	3.2*	7.1
6:31	7.2	7.2	9.6
7:01	7.2	7.0	7.6
7:31	7.6	7.4	7.6
8:01	Delay	7.6	7.6
8:31	in	7.2	7.4
9:01	process-	7.3	7.4
9:31	ing	7.3	7.6
10:01	7.8	9.2	7.3
10:31	7.9	8.8	9.2
11:01	7.4	7.4	7.9
11:31	8.1	8.0	7.6
12:01	7.8	8.6	10.4
12:31	7.5	8.8	11.2**
1:01	7.5	8.8	9.4**
1:31	7.4	-	9.6**
2:01	7.1	-	9.2
2:31	7.2	-	8.7
3:01	7.3	-	-
3:31	12.0**	-	-
4:01	8.7	-	-
4:31	8.2	-	-
5:01	-	-	-
5:31	-	-	-
6:01	-	-	-

*Acid sanitizing

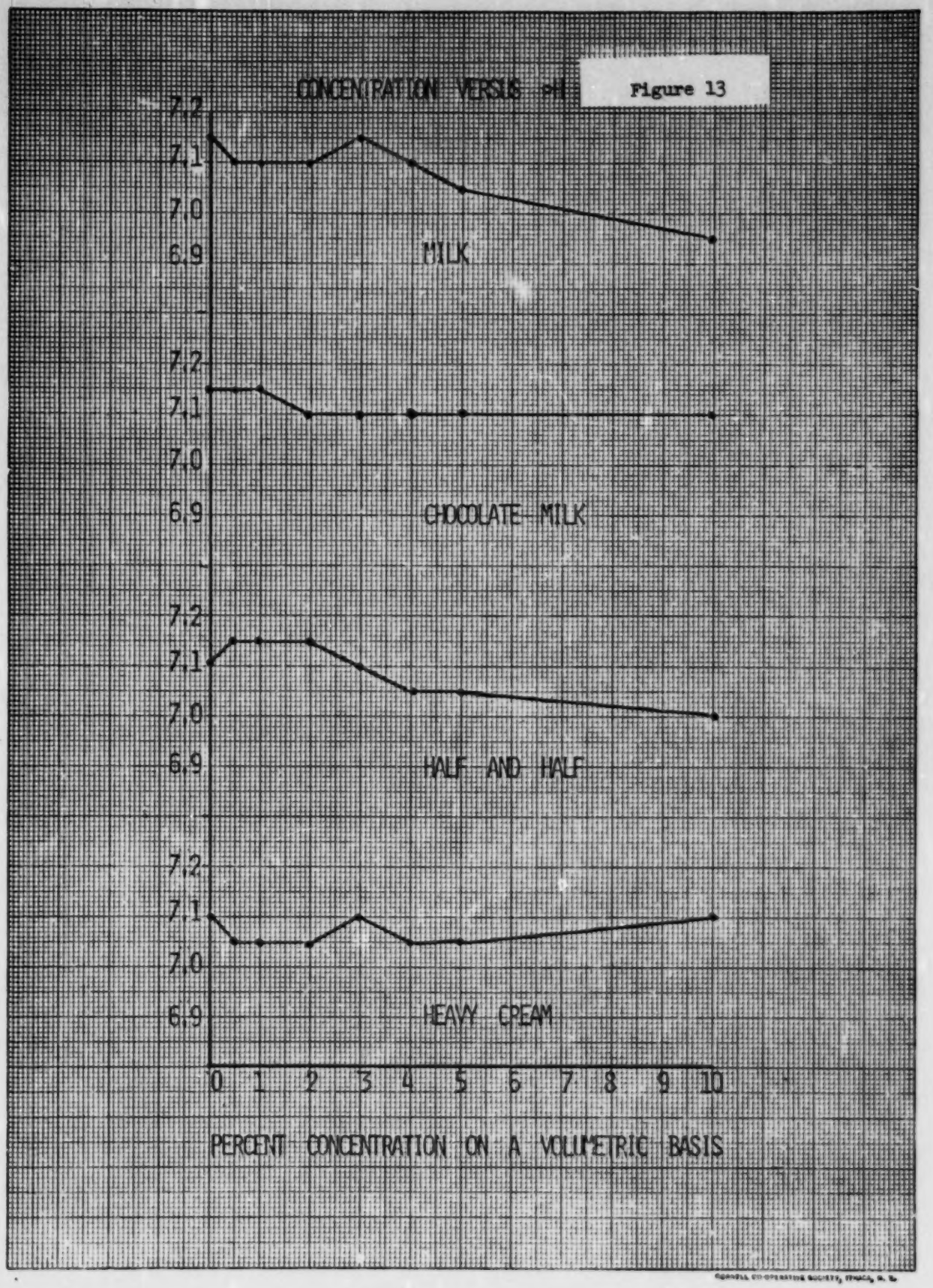
**CIP wash cycles

Table 7 pH READING USING A BECKMAN MODEL ZEROMATIC II pH METER

Concentration Percentage on a Volumetric Basis	Milk	Chocolate Milk	Half and Half	Heavy Cream
10.0	6.95	7.10	7.00	7.10
5.0	7.05	7.10	7.05	7.05
4.0	7.10	7.10	7.05	7.05
3.0	7.15	7.10	7.10	7.10
2.0	7.10	7.10	7.15	7.05
1.0	7.10	7.15	7.15	7.05
0.5	7.10	7.15	7.15	7.05
0.1	7.15	7.15	7.10	7.10

The type of water being discharged can influence the pH monitoring. Different pH values were found in raw cold water and hot water supplies. Another pH value was obtained in the condensate from steam used to heat cold water at the hose stations. Cold water pH was found to be 6.90 at the time of sampling. Hot water gave a pH value of 7.25, while the steam condensate was recorded at 6.50.

As indicated, the pH differences between water supplies were greater than the pH differences between 100 fold dilutions of the selected dairy products. For example, the pH of 0.1 percent milk was 7.15 and at 10 percent the value was 6.95; the difference was 0.20 units. Chocolate milk differences between the highest and lowest dilutions were only .05 pH units. Therefore the results strongly suggest minor value of pH as a measure of waste product concentration. The information given in Table 7 is presented in graphical form in Figure 13.


CONCENTRATION VERSUS pH
Figure 13
7.2
7.1
7.0
6.9
MILK
7.2
7.1
7.0
6.9
CHOCOLATE MILK
7.2
7.1
7.0
6.9
HALF AND HALF
7.2
7.1
7.0
6.9
HEAVY CREAM
0 1 2 3 4 5 6 7 8 9 10
PERCENT CONCENTRATION ON A VOLUMETRIC BASIS

Having once accepted, in principle, the concept of segregation, plant personnel were receptive to reusing other products within the plant. Detergents used to clean equipment were examined as follows:

Reduction in Use of Cleaning Compounds

The plant workers practiced reuse of some detergents. A CIP system for lines and storage tanks was installed with the equipment arranged to recirculate detergents back to a surge tank. Pre-rinses were automatically discharged to the sewers to prevent soiled dairy product wastes from mixing with the detergents. Peaks in flow and temperature of waste water caused by the process can be seen on Figures 5 to 10. In addition, a common wash tank was used for the Tetra-Pack and Poly-Gal machine. Initial solutions of the washing compound were prepared in concentrations of about 0.6 percent by hit or miss methods. The performance of the detergent was excellent and the cleaning of the equipment was satisfactory. Reductions in detergent strength occurred as follows: (Daily variations were very slight)

Initial solution	0.6%
After Poly-Gal wash-up	0.4%
After Tetra-Pack wash-up	0.2%

One third of the concentration was dissipated by each use and left a solution with one-third of its concentration still available for re-use. Final cleaning solution was still clear, with little or no solids, even though two-thirds of its concentration was spent.

The H.T.S.T. circulating material, a Cowles product called "Complete", was used in 2.5 percent concentration at a cost of thrity-seven cents per pound and was investigated for reuse characteristics.

Ten pounds of "Complete" were used daily to clean the pasteurizing units by heating the wash solution to 185 degrees and circulating it by a high speed pump through the system. Test methods indicated the depletion of cleaning strength was less than 0.1 percent and the appearance of the material was unchanged. The caustic solution was segregated by pumping the fluid into five stainless steel cans and then saved for reuse in the cleaning program. At first the saved material was used for washing vats and floors by further diluting the detergent to 0.75 percent strengths. In actual use it was found to be satisfactory for such cleaning.

In six consecutive operations, the detergent was reused to clean the plate heaters. Bacteriological samplings of the dairy products were analyzed to follow the clean-up efficiency. Solution strengths were maintained between 2.25 to 2.5 percent by occasional supplemental additions of "Complete". During the six day trial, five pounds were required in addition to the initial ten pound charge. In total, fifteen pounds of material were used for circulation cleaning versus the normal sixty pounds.

A check of products processed through the equipment for bacteriological results indicated no increase in standard plate counts. (See Table 8) Milk and by-products were maintained below one thousand organisms per ml. and negative coliform results were obtained by both plate and tube methods. Disassembly and inspection of the plate equipment showed excellent cleaning.

In normal practice, the plate heater was taken apart at three-week intervals to inspect the plates. This practice was not changed and the salvaged cleaning compounds were used in the last week of the

cycle. The compound salvaged at the end of the six circulation days was put to further use for floor scrubbing and cleaning a closeby sluggish sewer drain.

Table 8 PRODUCT QUALITY CONTROL

Date	Sample	S.P.C. 1-1000	Desoxycholate Plates 1cc Portion	Brilliant Green Bile 2% Tubes 1cc Portion
11/20/67	½ pt. milk	< 3000	2	+-
	½ pt. skim	< 3000	1	--
	½ pt. choc.	< 3000	1	--
11/22/67	qt. milk	< 3000	1	--
	½ pt. choc.	< 3000	1	--
11/27/67	½ pt. skim	< 3000	1	--
	½ pt. milk	< 3000	1	--
	½ pt. choc.	< 3000	1	--
11/29/67	½ pt. skim	< 3000	1	--
	½ pt. milk	< 3000	1	--
	½ pt. choc.	< 3000	1	--
	coffee cream	< 3000	1	--

Improving the Operational Economic Picture

Salvaged dairy products can be disposed of by the following alternative methods:

1. Use collected salvage material into existing products.
2. Create a new product to utilize the salvage.

3. Use rinsings obtained for animal feed.

4. Find a buyer for the diluted dairy product.

Efficiency Should Supersede Appearance

Many sites value pleasing equipment appearance more than ease of operation. It would be ideal if one could have both efficiency and a pleasing lay-out of the functional equipment in the plant. However, design and flow patterns should be governed by maximum plant efficiency.

Hose Stations

Many dairy plants are constructed so that supporting columns are needed within manufacturing areas. Older construction, and even those up-dated by the use of tile and false ceilings, have continued the use of the columns for obvious economic reasons. Evidently the columns also provide convenient locations for plumbing lines, support of electrical lines, and supports for product lines. Column located plumbing, coupled with long lengths of creamery hose, is most often the method used to make a source of water available to the plant worker for his needs in processing or clean-up operations.

One familiar with the operation of dairy plants knows that a hose is often dragged across floors before being inserted into a processing vat or similar piece of equipment where it is needed. The very nature of the hose to resist being stationary in the vat is such that it must be coiled around a flange or a thermometer. Most often the hose dangles sufficiently into the equipment to prevent its coming out when the water is turned on. Obviously such a practice is not sanitary and must contribute contamination to the product with many kinds of micro-organisms that could be detrimental.

Many hose stations, because of faulty valves, lack ease in turning the water on and off, thus causing temperature regulating difficulties. One can hardly expect the worker to walk back and forth adjusting temperature and still have him shut the water off when it is not needed. The view held by the investigator is that it would be best for the plant management to invest in additional piping and proper regulating valves to bring water directly to the place of use. The additional benefit of dry floors makes the work area less tiring for the employee as he is less prone to slipping and sliding.

Fat Losses

Operational records of the New York dairy plant in October 1967, list a fat loss of 359.32 pounds. The in-plant investigation found a potential salvage of 210 pounds (fifty pounds per week x 4.2 weeks/month) or sixty percent of the unaccounted loss. A major portion of the remaining fat loss was traced to package overweight, fat given away in products testing higher than intended, and some apparently inevitable losses to the sewers.

Value of Waste Monitoring

The plant management should employ instrumented data collection to scan the wastes being generated in the food plant on a twenty-four hour cycle. Information such as waste volume or temperature can be a vital tool to increase plant efficiency. Recorded data can provide information not only to increase product yields but to decrease service costs for fuel, water, etc.

Motivation of personnel for promoting more care in product handling is possible. Daily routine results will find valuable use in the operation to suppl ment other daily compiled information required to police and control the food plant.

Imagination can lead to many more ways of using segregated wastes than may have been suggested by the investigation. New by-products may be developed which can lead the firm into other revenue producing areas.

The detailed investigation of the single plant suggests the following recording monitoring guides. Simultaneously printed data should be recorded onto a multiple copy carbon strip chart to show the following:

1. Waste discharge volume in pounds or gallons
2. Waste discharge temperature in degrees Fahrenheit
3. Conductivity in micromhos

Such monitoring will initiate a screening program by the plant operator. The food plant should have an automatic sampling device to regularly obtain representative composite samples for further analysis such as BOD values to complete a waste management profile.

Table 9 ESTIMATED SAVINGS AVAILABLE AT PLANT WHEN RINSINGS ARE SALVAGED, DETERGENTS ARE REUSED, AND WATER WASTE IS REDUCED*

1967

Item	Per Week	Per Year
Dairy Products		
50 pounds of fat at 80¢/pound	$ 40.00	$2,080.00
125 pounds of S.N.F. at 20¢/pound	25.00	1,300.00
Detergents		
Circulation with used compound four times per week, results in a 30 pound saving per week.	11.10	577.20
Water		
Water savings at 15¢/1000 gallons* or 6000 gallons/day = 90¢/day on a 4½ day week.	4.05	210.60
Waste Handling Charges		
Waste handling charges 20¢/1000 gallons* or $1.20/day on a 4½ day week.	5.40	280.80
Fuel		
Fuel savings using oil at 10¢/gallon providing 140,000 BTU/gallon. 640,000 BTU can be saved per hour on the average; for a 12 hour operating day, 7,680,000 BTU can be converted to an oil saving of 54 gallons or $5.40/day on a 4½ day/week.	24.30	1,263.60
Total	$109.85	$5,712.20

*Minimum costs found in field survey of New York State food plants

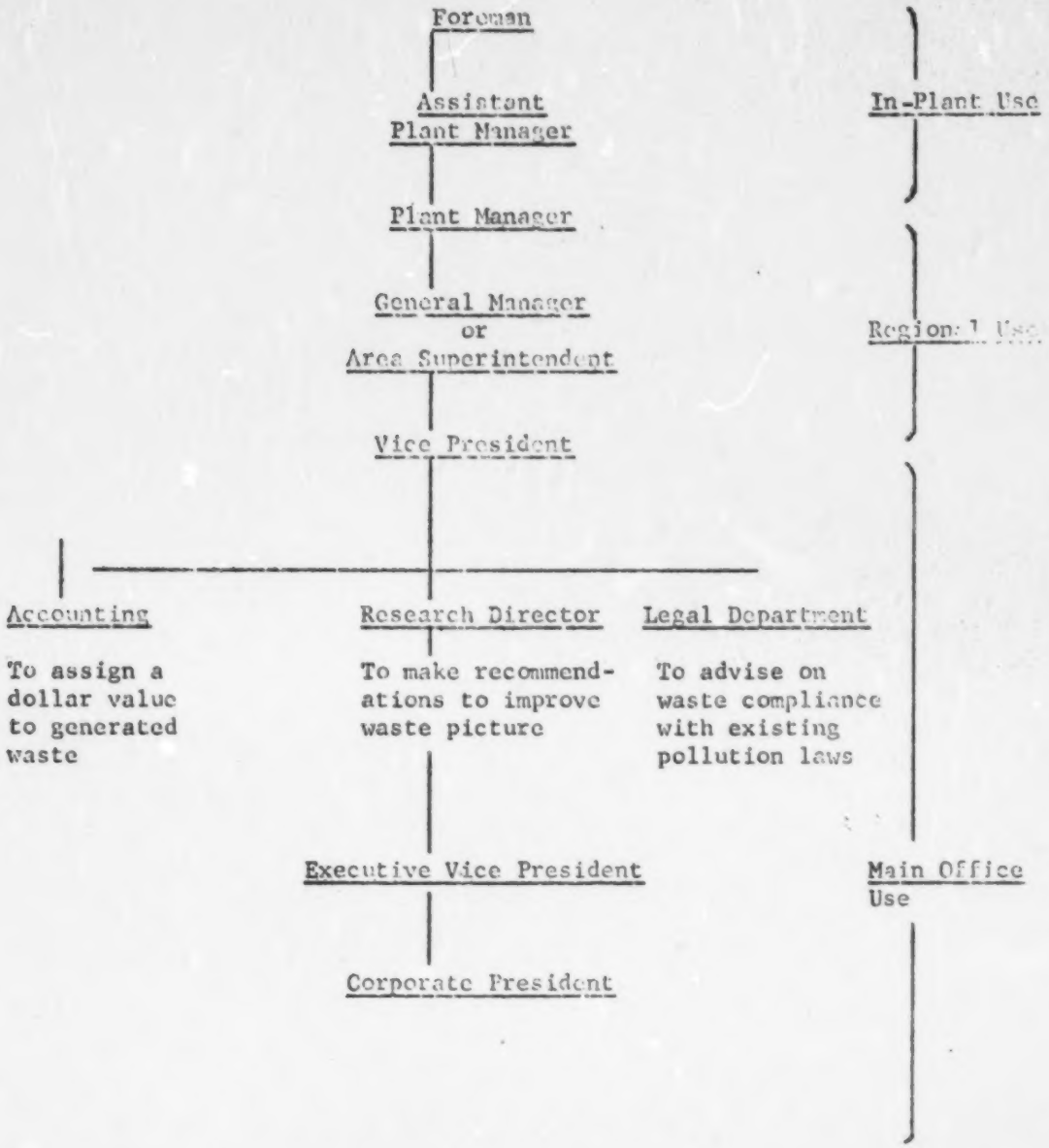
The dollar value of $5,712.20 itemized in Table 9 should be viewed as a departmental contribution saving for a larger dairy manufacturing complex. It should be noted that initial cost of weir and recording mechanisms approximates several hundred dollars. Educational program and continuing man hours needed to supervise program will be a variable expense depending upon the value of the time expended on this program versus hours spent on other activities.

Compiled recorded information should be reviewed by in-place supervisors and successive interested parties to fully exploit the gained knowledge. A suggested organizational personnel chart is illustrated in Figure 14.

Accounting techniques employed by the business firm have rigorously recorded the activity of business. Emphasis has been placed on detailed records which can substantiate incoming raw materials and outgoing finished goods. Dollar transactions are obviously checked and cross checked by dual bookkeeping methods.

In other forms of control, wire fences, supplemented by patrolling company guards, are often constructed to safeguard the firm against pilferage. Yet, unaccounted dollars, in the form of careless waste, often flow unseen below ground, unregulated and forgotten by too many company officials.

Figure 14 POSSIBLE WAY IN WHICH WASTE MONITORING INFORMATION MIGHT BE USED IN A LARGE CORPORATION



The case study information obtained at the small sized dairy was used to design a waste monitoring station for a large scale multi-product New York State dairy firm. The following pictures show how waste was divided into clean and dirty water. Flowing waste was measured with a Panshall Flume from which samples were collected for a composite sample proportional t flow. Biological and chemical analyses of the samplings were used to make appropriate in-house changes to improve the organization's waste profile picture. In fact the volume of flow was reduced from about 800,000 gallons per day to less than 175,000 gallons per day. In addition, further waste reduction has been achieved by continued improved management methods.

An interesting side piece of information came to light in the monitoring. Figure 18 shows an integrating mechanism that automatically computes waste water Btu content by measuring flow pounds X temperature rise above a preset raw water temperature base. Instead of obtaining positive figures as occurs in most locations, we obtained negative Btu values. This plant produces enormous amounts of cottage cheese and uses a chill water system to cool curd with ice water. We discovered that refrigerated cheese wash water was excessively used and this wasteful practice cooled combined waste flow temperature substantially below intake water temperature. Improvements were made in the processing method to capture more efficient refrigeration Btu transfers in cheese curd cooling.

Guidelines for constructing the waste monitoring tool were established by Dr. Zall. The dollar costs for the system approximated $3500 for equipment and $2500 for installation. The system provides the following:

(1) Measures flow from 0 gpm to 833 gpm using a 6" flume.

(2) Provides a flow, temperature, and Btu use records.

(3) Samples liquids proportional to flow.

(4) Provide a continuing meter reading similar to speedometer for long term reference periods.

SUMMARY

This seminar was developed to stress the economic pathways for salvage and reuse of raw materials and chemicals that are utilized in the manufacture of food products. Operators of dairy plants and allied food plants have the legal responsibility of refraining from contributing pollutants to the waters of the nation.

Evidence is presented to show the value of waste reduction, the value of volume reduction, and the value of product that can be salvaged to produce a revenue.

Part II singled out one processing plant which was subjected to measures emphasizing in-plant actions to minimize waste production. The New York plant reduced its waste volume by fifty percent. Segregation of product rinsing reduced the daily pounds of BOD generated by as much as fifty percent. In addition evidence was presented showing the value of detergent reuse when proper control information was developed.

We are suggesting a new use for waste recording information developed from monitoring waste effluents. The performance of management and production workers can be graded by waste production indices. Inexpensive equipment such as temperature recorders, conductivity scanners, and weir measuring devices can be used to pinpoint weaknesses in plant operations. Not only can waste handling costs to the firm be reduced, but in-plant savings of raw materials can produce a new source of revenue.

Figure 15. View of Shed Constructed to Hold Monitoring Equipment with Clean and Soiled Water Segregation Stations

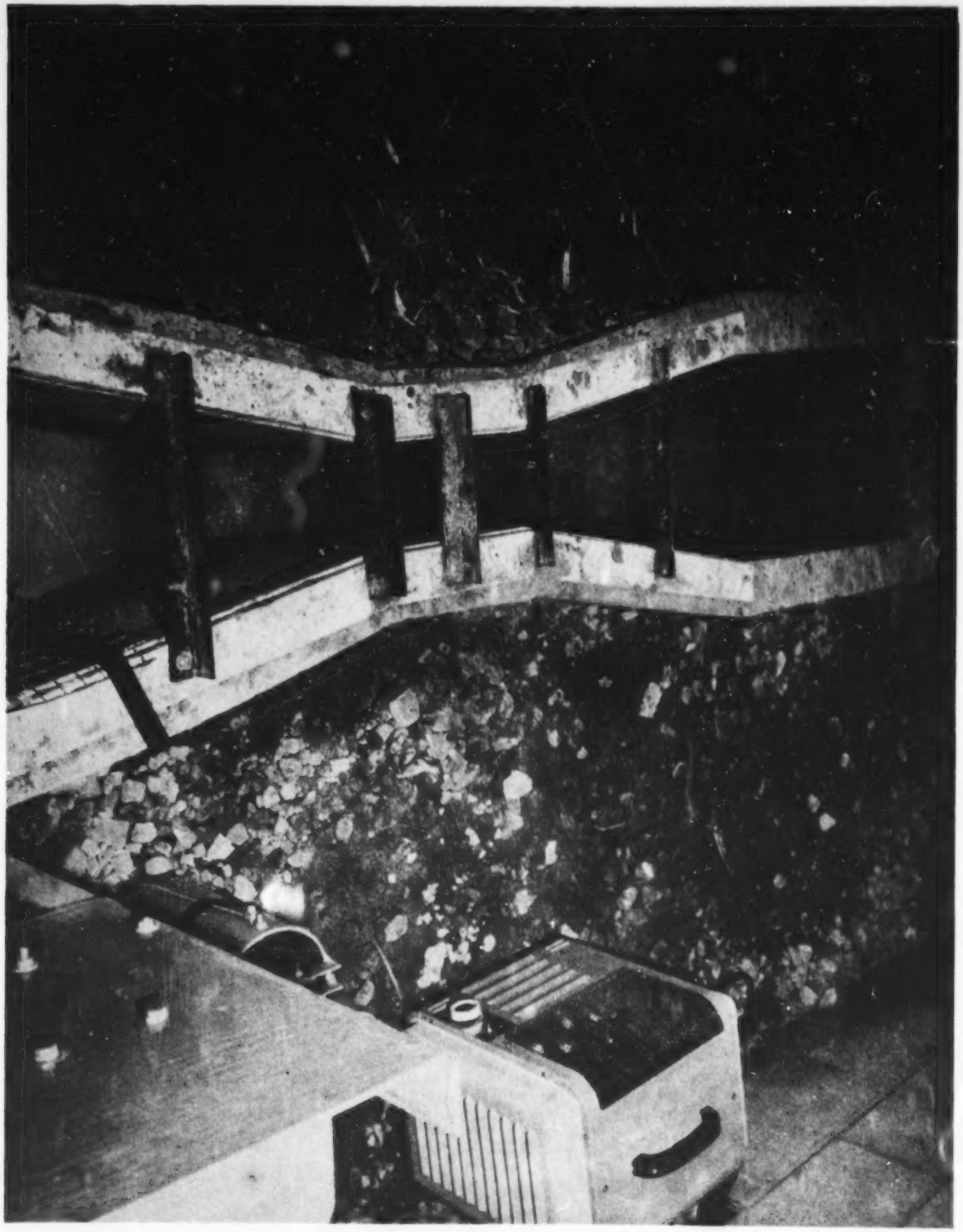


Figure 16. Closeup View of Parshall Flume

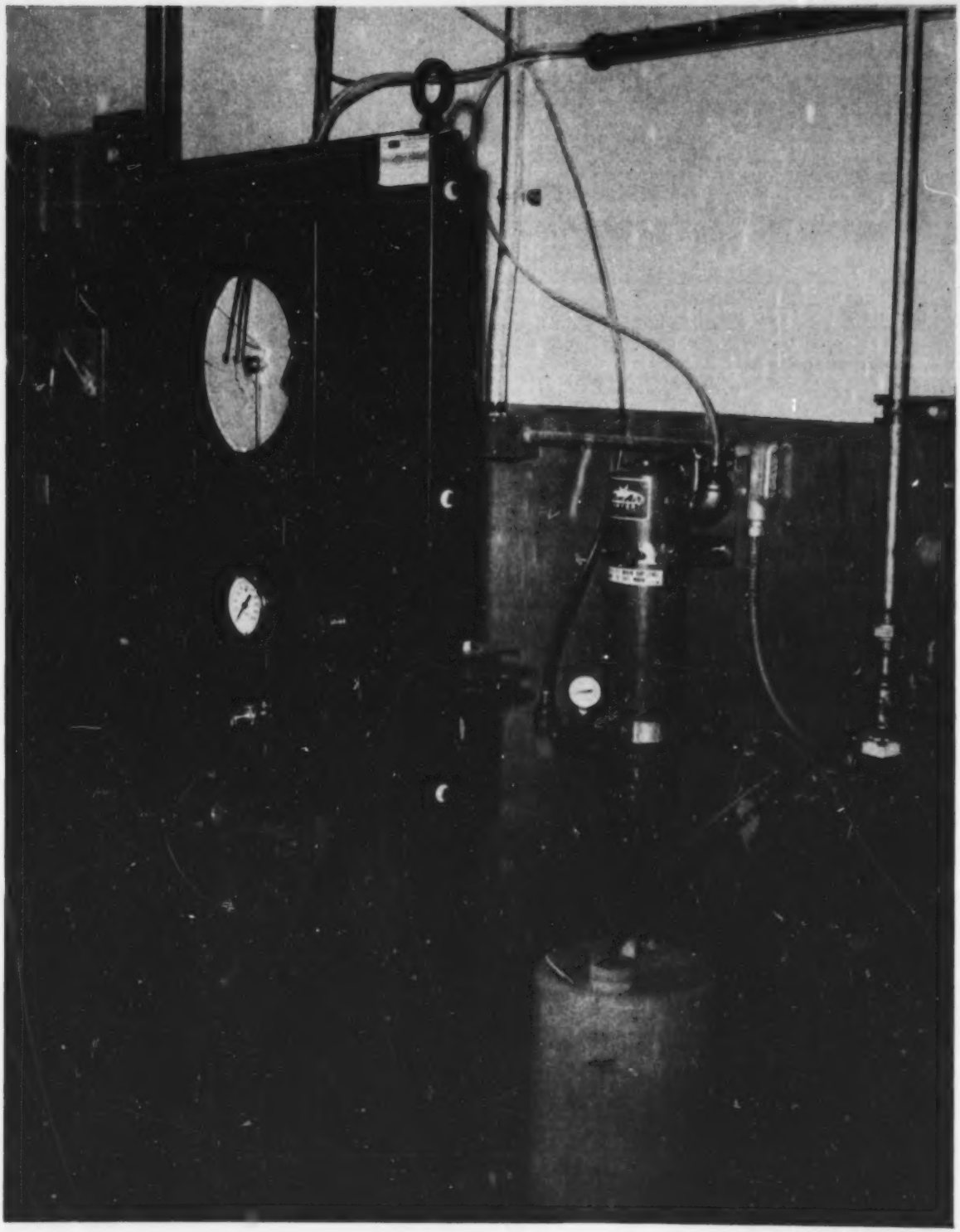


Figure 17. Recording Instrument and Composite Sampling Proportional to Flow

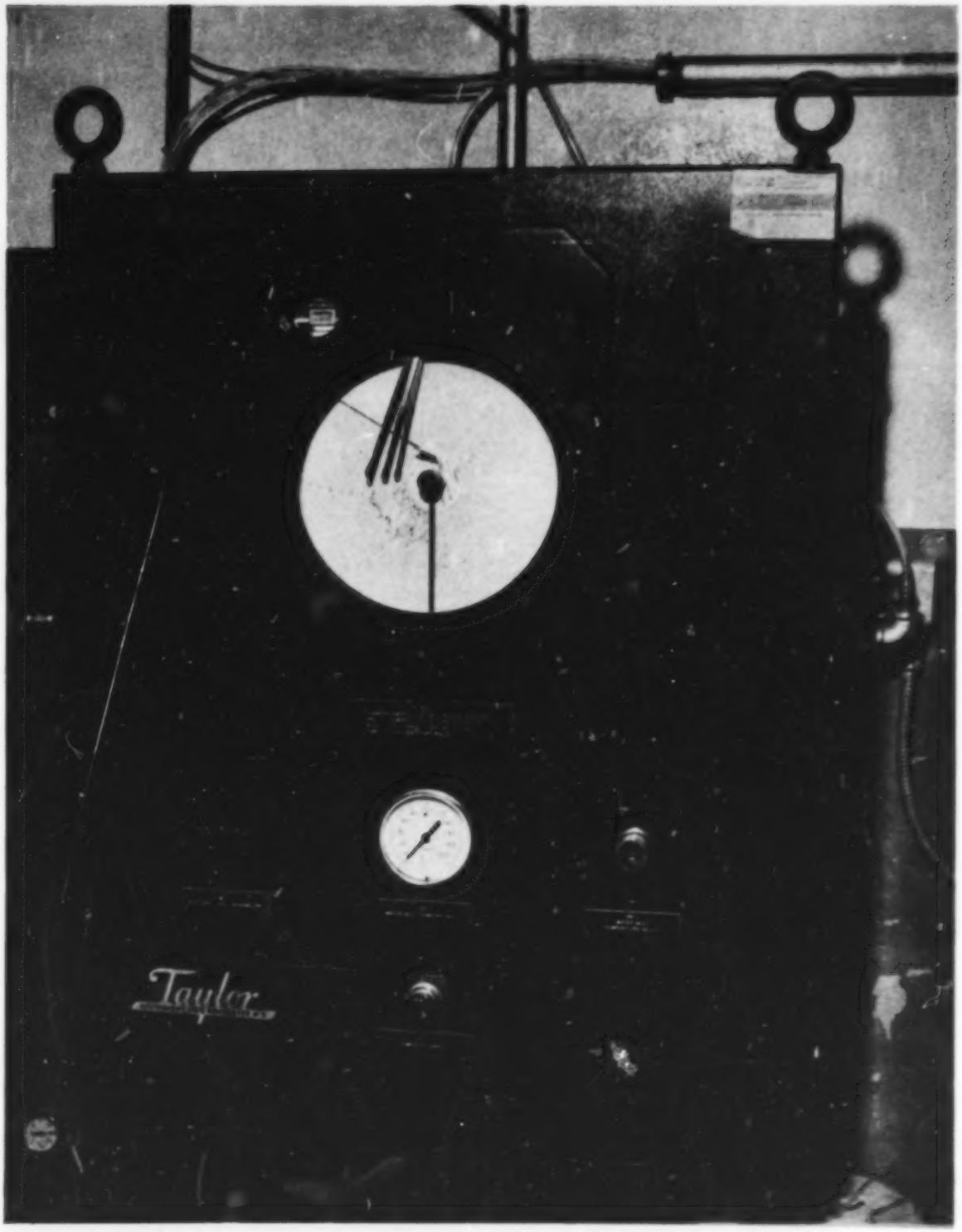


Figure 18. Closeup of Recording Instrument that also Computes Btu Loss in Waste

Appendix A

WASTE MEASUREMENT PANEL	APPLICATION DRAWING SED 34001-D

DESCRIPTION OF OPERATION

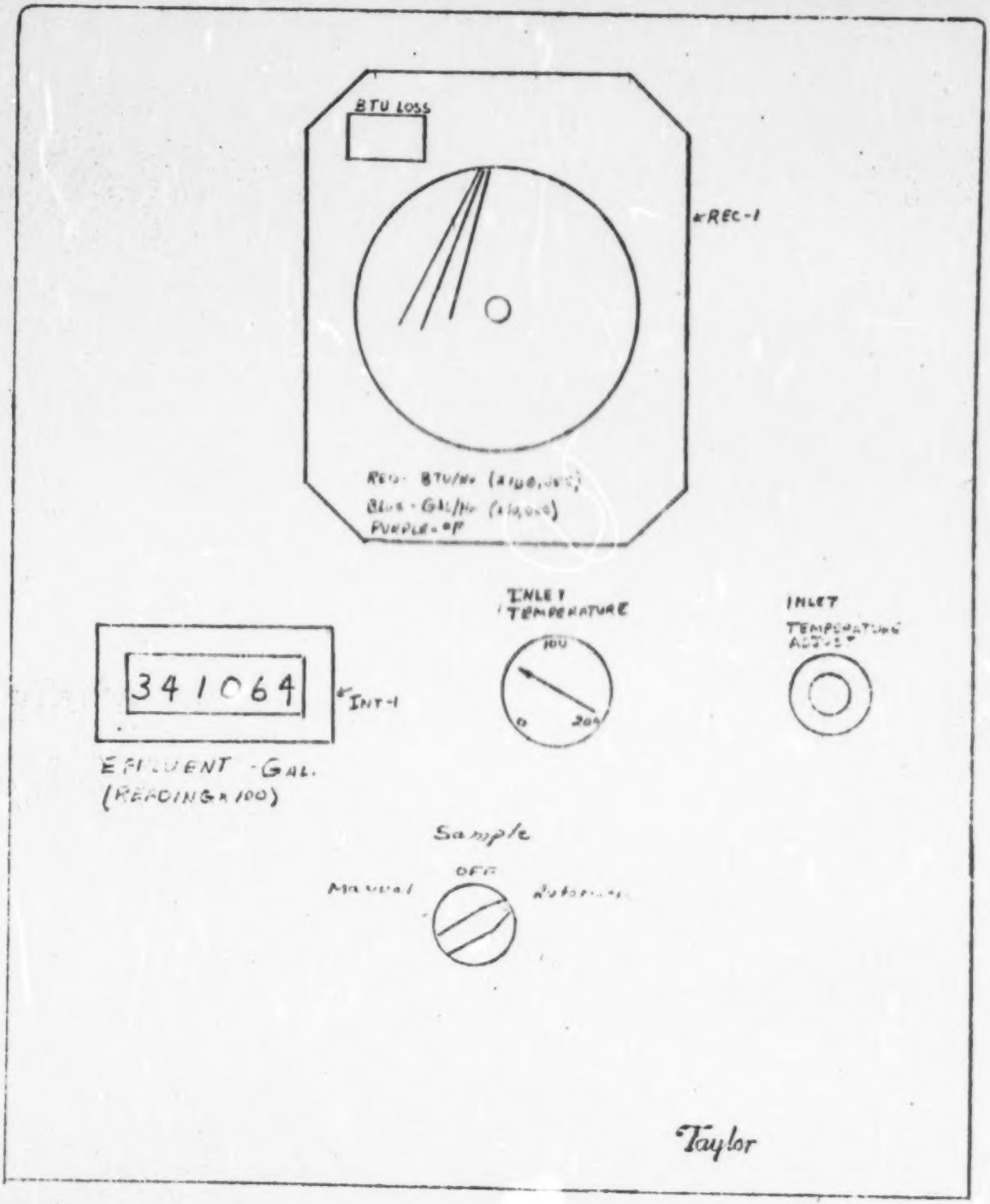
The flow of effluent is measured by a Differential Pressure Transmitter (200TD1103). The square root flow signal is linearized. The linearized signal is totalized and fed to an 87JE Recorder. Here the instantaneous flow is recorded.

The exit temperature is measured in a Sensaire Temperature Transmitter. The signal is fed to the 87JE and recorded. The inlet temperature is manually set. The two temperature signals and the flow signal are used to calculate the heat loss. This is recorded (87JE) and integrated.

A sampling system is provided to take a sample for each 100 gallons of effluent. This sample is a composite sample. Provision to take a sample manually is provided.

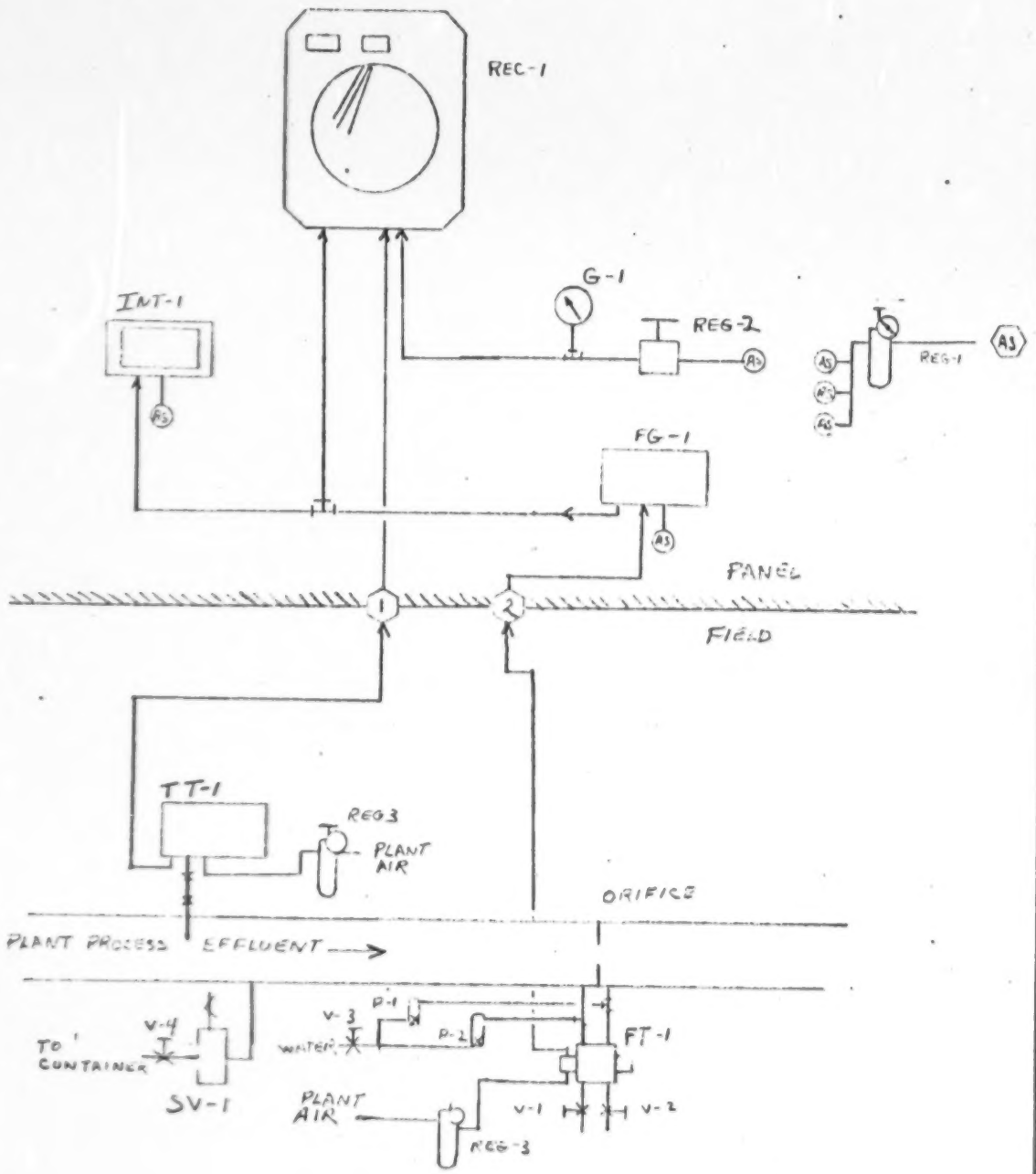
WASTE MEASUREMENT PANEL
PANEL FRONT FACE

APPLICATION DRAWING
SED 34001-A



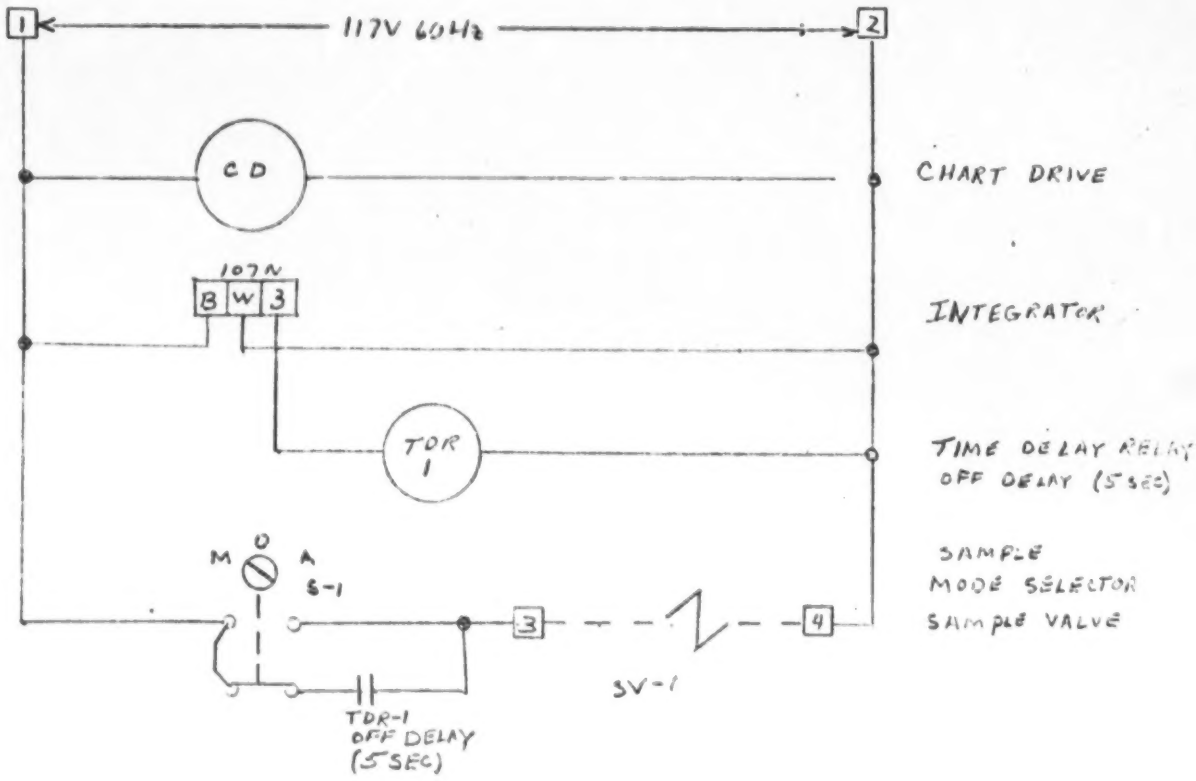
WASTE MEASUREMENT PANEL
SYSTEM SCHEMATIC

APPLICATION DRAWING
SED 34001-B



WASTE MEASUREMENT PANEL
ELECTRICAL SCHEMATIC

APPLICATION DRAWING
SED 34001C



REFERENCES

1. Allee, D.J. 1961. Government facilitation of irrigation in New York. Doctorial Thesis, Cornell Univ., Ithaca, N.Y.

2. Allen, L.A. 1964. Treatment and disposal of effluents. Dairy Ind. 29:90-93, 164-68, 176.

3. Anderson, M.E. and H.A. Morris. 1966. This problem of waste disposal. Mfg. Milk Products. 57:8.

4. Anon. 1967. Aerators solve waste treatment problem. Amer. Dairy Rev. 29(4):40.

5. Anon. 1966. New study on refuse and sludge disposal. (TVA Public Health Study.) J Milk Food Tech. 29(4):125.

6. Anon. 1966. Water desalting improved to bring production costs down. Water waste Eng. February.

7. Bacon, V.W. 1967. Sludge disposal land reclamation. Ind. Water Eng. April, p. 27-29.

8. Beardsley and Krotinger. 1955. Evaluation of odors. Sew. Ind. Wastes. 27(2).

9. Burch, J.E., E.S. Lipinsky, and J.H. Litchfield. 1963. Technical and economic factors in the utilization of waste products. Food Tech. 17(10):1266-1272.

10. Chapman, C.J. 1962. Pasture fertilization with sewage effluent irrigation. Compost Sci. 13(3).

11. Clews, John. 1961. Wastes from milk processing. Compost Sci. 12(2).

12. Conley, R.R. et al. 1967. Survival of pathogenic bacteria in waste stabilization ponds. J. of Dairy Bacteria. 29(5).

13. Dairy and Ice Cream Field. 1972. Environmental control and the dairy industry. 155(8). Special report in cooperation with IAICM/MIF.

14. Dietz, M.R. and R.C. Frodey. 1960. Cannery waste disposal by Gerber Products. Compost Sci. 11(3):22-26.

15. Ewbank, R.C. 1967. Ridge and furrow irrigation. Proc. 15th Dairy Eng. Conf.

16. Foster, E.M. et al. 1964. Dairy plant waste disposal and utilization of byproducts. Dairy Microbiol. pp. 459-477.

17. Frei, J.K. 1949. Use of chloroben for odor control. Sew. Works J. 21(1).

18. Froedge, Ralph. 1967. Activated sludge system of waste disposal. Proc. 15th Dairy Eng. Conf.

19. Fuller, J. and Jourdian. 1955. Efforts of dried sludge on nitrification in soil. Sew. Ind. Wastes. 27(2).

20. Goldsmith, R.L. et al. 1971. Membrane processing of cottage cheese whey for pollution abatement. 2nd Nat. Symp. on Food Proc. Wastes.

21. Green, R.L. 1952. Design considerations for sprinkler irrigation systems used for waste disposal. Agr. Eng. Dept., Univ. of Maryland.

22. Greiner, F.J. 1967. The dairy industry and environmental waste. 62nd Ann. Meeting A.D.S.A.

23. Haney, P.D. 1954. Theoretical principles of aeration. J. Amer. Water Works Assn. p. 353-375.

24. Harding, H.G. 1966. Water Quality Act of 1965-Impact on dairy and food industry. J. Milk Food Tech. 29(11):350-353.

25. Harper, W.J. and J.L. Blaisdell. 1971. Dairy food plant wastes and waste treatment practices. Water Poll. Cont. Series 12060 EGU 03/71. 560 p.

26. Heukelekian, H. 1963. Just how effective are lagoons? Compost Sci. 14(3).

27. Holland, R.F. 1972. Pollution and the dairy industry. Amer. Dairy Rev. 34(5):20-21.

28. Holland, R.F. and J.C. White. 1957. Disposal of dairy wastes. Amer. Milk Rev. 19(10):98.

29. Hoover, S.R., L. Jasewiez, and N. Porges. 1954. Biochemical oxidation of dairy wastes. Eastern Util. Res. Br., Agr. Res. Center, U.S.D.A. Philadelphia, Pa.

30. Horton, J.P. and H.A. Trebler. 1954. Recent developments in design of small milk waste disposal plant. J. Can. Dairy Ice Cream. 33(4):38-41.

31. Hurwitz, E. 1963. Conversion to an aerated lagoon extends pond's life. Water Sew. Works. October.

32. James, F. 1957. How to set up a dairy waste system. Milk Plant Monthly. 46(8):16-18.

33. Johnson, F.F. 1967. Dairy waste irrigation spray. Proc. 15th Dairy Eng. Conf.

34. Kardos, L.T. 1967. The living filter concept. Ann. Meeting N.E. Br. Amer. Soc. of Agron., Waste Water Removation and Conservation Res., Pennsylvania State Univ.

35. Knapp, C.E. 1971. Membrane processing upgrades food wastes. (Report about Zall.) Environ. Sci. Tech. 5(5):396-397.

36. Kountz, R.R. 1954. Big problem. Dairy wastes striking solution bio-oxidation. Food Eng. 26(10):89-90.

37. Kountz, R.R. 1954. Biological oxidation aerators. Pennsylvania State Univ.

38. Kountz, R.R. 1954. Great saving in new treatment of waste pilot plant operation of new biological oxidation principles. Milk Plant Monthly. 43(8):21-22.

39. Kountz, R.R. and N. Porges. 1956. Dairy waste treatment by aeration. Agr. Res. Serv., ARS-73-16.

40. Lawton, G.W. et al. 1960. Effectiveness of spray irrigation as a method for disposal of dairy plants wastes. Univ. of Wisconsin Eng. Exp. Sta. Res. Rep. No. 15.

41. Lloyd, G.T. and L. Royal. 1964. Simplified methods for control of creamery effluent. J. Soc. Dairy Tech. 17(2):111-112.

42. Maxie, R.B. 1964. Potential microbial contamination from dairy equipment with automated circulation cleaning. J. Milk Food Tech. 27(5):135-139.

43. Maxie, R.B. and K.M. Shahani. 1961. Cleaning and sanitation of welded line systems for handling milk. J. Milk Food Tech. 24(4):122-127

44. McCarty, P.L. 1970. Biological treatment of food processing wastes. 2nd Nat. Symp. on Food Proc. Wastes-April 6, 1968.

45. McKee, F.J. 1955. Spray irrigation for disposal of milk wastes. Kraft Foods Co., Chicago, Ill.

46. Mickelsen, R. 1967. Estimating cost of treating dairy plant waste materials. Amer. Dairy Rev. 29(4):36-37.

47. Mitchell, W.D. and N.G. Cassidy. 1966. Utilization of casein wastes for pasture irrigation. 17th Int. Dairy Cong. Sec. F(6):745-752.

48. Morgan, P.E. 1957. The cost of milk waste treatment. Amer. Milk Rev. 19(6).

49. Muers, M.M. 1965. Dairy water conservation and effluent disposal. J. Soc. Dairy Tech. 18(1):3-14.

50. Muers, M.M. 1955. Effluent large and small dairies. J. Soc. Dairy Tech. 8(11):34-40.

51. Murdock, H.R. 1952. Dairy waste produces a high protein sludge containing vitamin B12. Ind. Eng. Chem. 44, Suppl. 99A-100A.

52. New York State Water Pollution Control Board. 1959. Efficiency of various methods of treatment-Milk plant wastes, New York State, Res. Rpt. No. 2.

53. New York State Water Pollution Control Board. 1959. Experimental treatment plant at Dutch Hollow Foods, Inc., Honeoye Falls, N.Y. Res. Rpt. No. 13.

54. Orchard, R.L. 1972. Wastes and effluents requirements of the dairy industry. Amer. Dairy Rev. 34(5):45-57.

55. Porges, N. 1953. A microbiological process report: Aerobic treatment of wastes. Appl. Microbiol. 1(5):262-270.

56. Porges, N. 1958. Practical application of lab data to dairy waste treatment. Food Tech. 12(2):78-80.

57. Porges, N. 1952. Successful treatment of dairy waste by aeration. Sew. Ind. Wastes. 24:874, 1144S.

58. Porges, N. 1956. Waste treatment by optimal aeration-Theory and practice in dairy waste disposal. J. Milk Food Tech. 19(2):34-38.

59. Porges, N., T.S. Michaner, L. Jasewicz, and S.B. Hoover. 1961. Dairy waste treatment by aeration-Theory, design, construction, operation. Agr. Handbook No. 176. U.S.D.A.

60. Porges, N., J.B. Pepinsky, and L. Jasewicz. 1951. Feed yeast from dairy by-products. J. Dairy Sci. 34(6):615-621.

61. Royal, L. 1964. The control of dairy effluent. Milk Ind. 55:36-41.

62. Sharkaw, F.M. 1970. Stabilization of dairy wastes by algal-bacteria symbiosis in oxidation ponds. J. Water Poll. Cont. Fed. 42:115-125.

63. Stanton, J.H. and G.A. Smith. 1967. Increasing C.I.P. efficiency. Wyandotte Sani Facts. No. 2.

64. Trebler, H.A. and H.G. Harding. 1955. Funademental of the control and treatment of dairy waste. Sew. Ind. Wastes. 27:1369-1382.

65. Twigg, B.A. 1967. Water use and conservation in food processing plants. J. Milk Food Tech. 30(7):222-223.

66. Watson, C.W. 1955. In plant control of dairy wastes. Sew. Ind. Wastes. 27(1):55-60.

67. White, J.C. 1965. Dairy waste disposal costs. Amer. Dairy Rev. 27(1).

68. Wisniewski, T.F. 1965. What's being done in Wisconsin about dairy waste disposal? Mfg. Milk Prod. 56(5):6-8.

69. Zall, R.R. 1972. Characteristics of milking center waste effluent from New York State farms. J. Milk Food Tech. 35(1):53-55.

70. Zall, R.R. 1970. Economics in cultured products processing. Cultured Dairy Prod. J. 5(4):8-11.

71. Zall, R.R. 1967. The problem and potential of 3,000,000,000 gallons of whey. Milk Dealer. 56(3):17.

72. Zall, R.R. 1969. Utilization of dairy waste. Cultured Dairy Prod. J. 4(2):12-13.

73. Zall, R.R. and W.K. Jordan. 1969. Monitoring milk plant waste effluent-A new tool for plant management. J. Milk Food Tech. 32(6):197-202.